Chick-fil-A Nutrition Plan

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Introduction. Chick-fil-A is a American fast food restaurant best known for their chicken sandwiches. On the Georgia College campus, there is a Chick-fil-A in the Bobcat Foodcourt where students enjoy eating. This restaurant is a popular choice among students. Chick-fil-A offers a fast food option that students can bring to class. In this project, we examine whether or not students that eat solely at Chick-fil-A can get a balanced diet with the proper nutrition according to the FDA. A lack of a proper nutrition can lead to serious health risks. For example, high blood pressure, high cholesterol, cardiovascular disease, and type two diabetes have been linked to poor diet and low exercise (Livestrong).

Diet Analysis. Nutrition information for all of the menu items sold at the Georgia College Chick-fil-A was found on the Chick-fil-A website and a list of these menu item is presented below,

chicken sandwich	chicken biscuit
hot buttered biscuit	hash browns
chick-minis(3-count)	chick-minis(4-count)
sausage, egg & cheese biscuit	chargrilled chicken sandwich
Chick-fil-A nuggets(8-count)	Chick-fil-A nuggets(12-count)
chargrilled chicken salad	chicken sandwich deluxe
garden salad	fresh squeezed lemonade(small)
fresh squeezed lemonade(medium)	fresh squeezed lemonade(large)
fresh brewed tea(small)	fresh brewed tea(medium)
fresh brewed tea(large)	coke drink(small)
coke drink(medium)	coke drink(large)
waffle potato fries(medium)	waffle potato fries(large)

According to the FDA, a balanced, two thousand calorie diet requires the following nutrition bounds

Nutritioin	Daily Values
Fat	$\leq$ 65 grams
Saturated fat	$\leq$ 20 grams
Cholesterol	$\leq$ 300 milligrams
Sodium	$\leq$ 2400 milligrams
Carbohydrate	$\leq$ 300 grams
Fiber	$\geq$ 25 grams
Protein	$\geq$ 50 grams
Vitamin A	$\geq$ 5000 International Units
Vitamin C	$\geq$ 60 milligrams
Calcium	$\geq$ 1000 milligrams
Iron	$\geq$ 18 milligrams
Sugar	$\leq$ 40 milligrams

We have two goals. One is to see if there is a feasible solution to the Chick-fil-A diet plan. That is, whether or not a balanced, two thousand calorie diet can be constructed by eating at only Chick-fil-A. If there is a feasible solution, the second goal is to minimize the cost across all possible Chick-fil-A diet options. Furthermore, the constraints for this model are formed by the recommended intake of nutrition levels. For example, calories form one constraint equation for the diet model. Let the number of calories in item i be a_i and let x_i be the quantity of item i purchased. We consider 24 menu options at Chick-fil-A so $1 \leq i \leq 24$. Note that x_i is a nonegative real number for all i. This leads to the following constraint which forces any diet at Chick-fil-A to have exactly 2000 calories

$$a_1x_1 + a_2x_2 + \ldots + a_{24}x_{24} = \sum_{i=1}^{24} a_ix_1 = 2000.$$

Similarly, the rest of the constraints are,

$$\begin{aligned}
\sum_{i=1}^{24} a_ix_i &= 2000 && \text{(Calories)} \qquad (1)\\
20 \leq \sum_{i=1}^{24} b_ix_i &\leq 65 && \text{(Fat)}\\
\sum_{i=1}^{24} c_ix_i &\leq 20 && \text{(Saturated fat)}\\
\sum_{i=1}^{24} d_ix_i &\leq 300 && \text{(Cholesterol)}\\
500 \leq \sum_{i=1}^{24} e_ix_i &\leq 2400 && \text{(Sodium)}
\end{aligned}$$

$$
\begin{aligned}
200 \leq \sum_{i=1}^{24} f_i x_i \leq 300 & \qquad \text{(Carbohydrates)} \\
25 \leq \sum_{i=1}^{24} g_i x_i & \qquad \text{(Fiber)} \\
50 \leq \sum_{i=1}^{24} h_i x_i & \qquad \text{(Protein)} \\
5000 \leq \sum_{i=1}^{24} j_i x_i & \qquad \text{(Vitamin A)} \\
60 \leq \sum_{i=1}^{24} k_i x_i & \qquad \text{(Vitamin C)} \\
1000 \leq \sum_{i=1}^{24} l_i x_i & \qquad \text{(Calcium)} \\
18 \leq \sum_{i=1}^{24} m_i x_i \leq 45 & \qquad \text{(Iron)} \\
\sum_{i=1}^{24} n_i x_i \leq 40 & \qquad \text{(Sugar)} \\
x_i \geq 0, \qquad 0 \leq i \leq 24 &
\end{aligned}
$$

Let the cost of item i be p_i. Therefore, the Chick-fil-A diet problem can be formulated as the following linear programming problem,

$$
\begin{aligned}
\text{Minimize } & \sum_{i=1}^{24} p_i x_i \\
\text{Subject to } & (1)
\end{aligned}
$$

We use a program called AMPL to solve this problem. Using AMPL, the Chick-fil-A diet problem is shown to be infeasible. We obtain a feasible diet if, for example, we ignore sodium, fiber and calcium. This is shown in the following table

x_1	0	x_{13}	0
x_2	0	x_{14}	0
x_3	0.88327	x_{15}	0
x_4	0	x_{16}	0
x_5	1.99169	x_{17}	0
x_6	0	x_{18}	0
x_7	0	x_{19}	0
x_8	2.19259	x_{20}	0
x_9	0	x_{21}	0
x_{10}	0	x_{22}	0
x_{11}	0.981988	x_{23}	0
x_{12}	0	x_{24}	0

where

x_3 = hot buttered biscuit
x_5 = chick-minis(3-count)
x_{11} = chargrilled chicken salad
x_{24} = waffle potato fries(large)

and the resulting price of this combination is \$19.77.

We also consider Subway, another restaurant in the Bobcat food-court. Nutrition information for the Subway menu items was found on the Subway website. As with Chick-fil-A, we only consider Subway items that are sold in the Bobcat Foodcourt. These items are shown below.

sweet onion chicken teriyaki (12 in)	roast beef(12 in)
subway club (12 in)	chicken & bacon ranch melt (6 in)
steak & cheese (6 in)	subway melt (6 in)
subway seafood sensation (6 in)	big philly cheesesteak (12 in)
big philly cheesesteak (6 in)	oven roasted chicken (12 in)
tuna sandwich (12 in)	turkey breast (6 in)
turkey breast & black forest ham (6 in)	Italian B.M.T. (6 in)
buffalo chicken (12 in)	buffalo chicken (6 in)
B.L.T. (12 in)	black forest ham (12 in)
black forest ham (6 in)	cold cut combo (12 in)
cold cut combo (6 in)	egg & cheese omelet (12 in)
egg & cheese omelet (6 in)	veggie delite (12 in)
veggie delite (6 in)	spicy italian (12 in)
meatball marinara (6 in)	tuscan chicken melt (12 in)
tuscan chicken melt (6 in)	chipotle steak & cheese (12 in)
chipotle steak & cheese (6 in)	steak & bacon melt (12 in)
steak & bacon melt (6 in)	kids-veggie delite
kids-turkey breast	kids-black forest ham
veggie delite salad	turkey breast salad

Using AMPL, it can be shown that the Subway diet problem is also infeasible. In particular, the sodium constraint is always violated. A feasible solution can be found if sodium is removed so we rephrase the objective function to minimizing sodium rather than minimizing cost. When this is done, we obtain the optimal solution,

x_1	0	x_{21}	0
x_2	0.338936	x_{22}	0
x_3	0	x_{23}	0
x_4	0	x_{24}	0
x_5	0	x_{25}	2.94511
x_6	0	x_{26}	0
x_7	0	x_{27}	0
x_8	0	x_{28}	0
x_9	0	x_{29}	0
x_{10}	0	x_{30}	0
x_{11}	2.21564	x_{31}	0
x_{12}	0	x_{32}	0
x_{13}	0	x_{33}	0
x_{14}	0	x_{34}	0
x_{15}	0	x_{35}	0
x_{16}	0	x_{36}	0
x_{17}	0	x_{37}	0
x_{18}	0	x_{38}	0
x_{19}	0	x_{39}	1.0726
x_{20}	0	x_{40}	0

where

x_2 =roast beef sub(12 in)
x_{17} = B.L.T. (12 in)
x_{20} = cold cut combo (12 in)
x_{20} = egg & cheese omelet (12 in)
x_{30} = chipotle steak & cheese (12 in)
x_{39} =veggie delite salad

with a optimal solution of 2841.63.

As a third dinning option, we consider the combined menus of Chick-fil-A and Subway. That is, we formulate the diet problem based on all menu items at the Georgia College Chick-fil-A and Subway. This diet problem can be expressed as the following linear programming problem

$$
\begin{aligned}
& \sum_{i=1}^{64} p_i x_i \qquad \text{(Minimize)} \\
20 \leq & \sum_{i=1}^{64} b_i x_i \leq 65 \qquad \text{(Fat)} \\
& \sum_{i=1}^{64} c_i x_i \leq 20 \qquad \text{(Saturated fat)} \\
& \sum_{i=1}^{64} d_i x_i \leq 300 \qquad \text{(Cholesterol)} \\
500 \leq & \sum_{i=1}^{64} e_i x_i \leq 2400 \qquad \text{(Sodium)} \\
200 \leq & \sum_{i=1}^{64} f_i x_i \leq 300 \qquad \text{(Carbohydrates)} \\
25 \leq & \sum_{i=1}^{64} g_i x_i \qquad \text{(Fiber)} \\
50 \leq & \sum_{i=1}^{64} h_i x_i \qquad \text{(Protein)} \\
5000 \leq & \sum_{i=1}^{64} j_i x_i \qquad \text{(Vitamin A)} \\
60 \leq & \sum_{i=1}^{64} k_i x_i \qquad \text{(Vitamin C)} \\
1000 \leq & \sum_{i=1}^{64} l_i x_i \qquad \text{(Calcium)} \\
18 \leq & \sum_{i=1}^{64} m_i x_i \leq 45 \qquad \text{(Iron)} \\
& \sum_{i=1}^{64} n_i x_i \leq 40 \qquad \text{(Sugar).}
\end{aligned}
$$

where p_i are the prices of items. Using AMPL, the following optimal solution was found,

x_1	0	x_{17}	0	x_{33}	0	x_{49}	0
x_2	0	x_{18}	0	x_{34}	0	x_{50}	0
x_3	0	x_{19}	0	x_{35}	0	x_{51}	0
x_4	0	x_{20}	0	x_{36}	0	x_{52}	0
x_5	0	x_{21}	0	x_{37}	0	x_{53}	0
x_6	0.961076	x_{22}	0	x_{38}	0	x_{54}	0
x_7	0	x_{23}	0	x_{39}	0	x_{55}	0
x_8	0	x_{24}	1.32102	x_{40}	0	x_{56}	0
x_9	0	x_{25}	0	x_{41}	0	x_{57}	0
x_{10}	0	x_{26}	0	x_{42}	0	x_{58}	0
x_{11}	0	x_{27}	0	x_{43}	0	x_{59}	0
x_{12}	0	x_{28}	0	x_{44}	0	x_{60}	0
x_{13}	0.656971	x_{29}	0	x_{45}	0	x_{61}	0
x_{14}	0	x_{30}	0	x_{46}	0	x_{62}	0
x_{15}	0	x_{31}	0	x_{47}	0	x_{63}	0.192079
x_{16}	0	x_{32}	0	x_{48}	1.95643	x_{64}	0

where

x_6 = chick-minis(4 count)
x_{13} = garden salad
x_{24} = waffle potato fries(large)
x_{48} = veggie delite (12 inch)
x_{63} = veggie delite salad

with a optimal price of \$17.69.

Lastly, we consider the combined menus for Subway and Chick-fil-A but with the restriction of x_i be integers. This changes the previous linear programming problem into a integer programming problem. Using AMPL, the following solution was found

x_1	0	x_{17}	0	x_{33}	0	x_{49}	0
x_2	0	x_{18}	0	x_{34}	0	x_{50}	0
x_3	0	x_{19}	0	x_{35}	0	x_{51}	0
x_4	0	x_{20}	0	x_{36}	0	x_{52}	0
x_5	0	x_{21}	0	x_{37}	0	x_{53}	0
x_6	1	x_{22}	0	x_{38}	0	x_{54}	0
x_7	0	x_{23}	2	x_{39}	0	x_{55}	0
x_8	0	x_{24}	0	x_{40}	0	x_{56}	0
x_9	0	x_{25}	0	x_{41}	0	x_{57}	0
x_{10}	0	x_{26}	0	x_{42}	0	x_{58}	0
x_{11}	0	x_{27}	0	x_{43}	0	x_{59}	0
x_{12}	0	x_{28}	0	x_{44}	0	x_{60}	1
x_{13}	0	x_{29}	0	x_{45}	0	x_{61}	0
x_{14}	0	x_{30}	0	x_{46}	0	x_{62}	0
x_{15}	0	x_{31}	0	x_{47}	0	x_{63}	4
x_{16}	0	x_{32}	0	x_{48}	1	x_{64}	0

where

x_6 = chick-minis(4 count)
x_{23} = waffle potato fries(medium)
x_{48} = veggie delite (12 inch)
x_{60} = kids-veggie delite
x_{63} = veggie delite salad

with a optimal price of $35.65

While this project is a good source of finding a healthy nutrition there are some weakness. In the Chick-fil-A menu, we ignore some of the soft drinks. For the Subway menu, we assume that all of the subs have the recommended toppings. However, these linear and integer programming problems provide well-balanced meals for Georgia College students looking to eat food that they like at the lowest cost possible.

This work can be extended to dining options at The MAX dinning hall. The MAX is a place where students regular go to eat because of the variety of food and the fast service. In a similar fashion, we would collect all the nutritional data for the food at The MAX and try to find an optimal diet.

Eating a well-balanced meal at Chick-fil-A or Subway is impossible, but if you eat at both, it can be done. It can also be done if you want to eat only integer amounts of food.

References

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