Project 2 - Minimum Cost Diet LP

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THIS REPORT DESCRIBES A LINEAR PROGRAM to minimize the cost of a day worth of food while meeting the RDA's reccommended daily nutritional targets. The food items looked at are: beans, rice, spinach, avocado, and cheese. The nutritional targets looked at are: Calories, Protein, Sodium, Vitamin A, Vitamin C, and Saturated Fat.

1 SETUP

Using data from the United States Department of Agriculture, I downloaded nutritional information for five food items, and stored them in *.csv* format in the /Data section of my project directory. I imported the *.csv* files using Python in /Code/parse_data.py, and organized the nutritional information according to certain nutritional properties: Protien, Calories, Vitamin C, Vitamin D, Sodium, and Saturated Fat. In the /Code/script.py file, I imported the organized data and added the PulP library to manage the details of the linear program.

To run the program, unzip the file and run the following commands:

```
cd Code/
pip install pulp
python script.py
```

1.1 NUTRITIONAL INFORMATION

See Figure 1.1 for details on the nutritional content of the five target foods, and the cost of each of the food items.

	Cheese	Rice	Beans	Avocado	Spinach
Serving Size (g)	28.0	42.0	130.0	136.0	340.0
Protein	7.0	3.0	10.0	2.67	9.72
Calories	110.0	150.0	150.0	227.0	78.0
Sodium	180.0	0.0	341.0	11.0	269.0
Vitamin A	589.0	0.0	0.0	200.0	31882.0
Vitamin C	0.0	0.0	0.0	12.0	95.5
Saturated Fat	5.001	0.0	0.0	2.891	0.214

(a) Nutritional Information in milligrams

Food	Dollar cost per pound
Cheese	7.71
Rice	1.00
Beans	1.00
Avocado	1.25
Spinach	7.00

(b) Food Costs

Figure 1.1: Nutritional information and cost of food items

1.2 VARIABLES

The individual food items were set up as real-valued variables in the linear program. The following lists the variables that were given as output to the program:

```
Foods_avocado  Continuous
Foods_beans  Continuous
Foods_cheese  Continuous
Foods_rice  Continuous
Foods_spinach  Continuous
```

1.3 OBJECTIVE FUNCTION

The objective function was generated by mapping the variables to their corresponding costs. The cost first had to be converted from cost per pound, to cost per gram, and then scaled to the serving size of the food item in the nutritional information. The conversion amount used was 453.5924 grams per 1 pound. The following objective function was used by the program:

```
0.7495716418529059*Foods_avocado +
0.2866009218849346*Foods_beans +
0.4759339001270745*Foods_cheese +
0.09259414399359425*Foods_rice +
5.247001492970341*Foods_spinach +
0.0
```

1.4 Constraints

Six contraints were added to the linear program - one for each nutritional property. For each nutritional property (e.g. Protien, Calories, ... etc.), the variables were matched with the corresponding food item's nutritional information (e.g. variable 'cheese' was associated with the amount of protein in cheese). The sum of the variable-coefficient pairs was then compared to the daily value of each nutritional property. The daily nutritional values are given in (1.1) below, and the full list of program constraints is in (1.2).

$$
\begin{aligned}
Calories &= 2000 \\
Protein &\leq 56 \\
Sodium &\leq 2400 \\
VitaminC &\geq 90 \\
VitaminA &\geq 700 \\
SaturatedFat &\leq 20
\end{aligned}
\tag{1.1}
$$

$$
\begin{aligned}
2000 &= 227(Avocado) + 150(Beans) + 110(Cheese) + 150(rice) + 78(Spinach) \\
56 &\geq 2.67(Avocado) + 10(Beans) + 7(Cheese) + 3(Rice) + 9.72(Spinach) \\
2400 &\geq 11(Avocado) + 341(Beans) + 180(Cheese) + 269(Spinach) \\
90 &\leq 12(Avocado) + 95.5(Spinach) \\
700 &\leq 200(Avocado) + 589(Cheese) + 31882(Spinach) \\
20 &\geq 2.891(Avocado) + 5.001(Cheese) + 0.214(Spinach)
\end{aligned}
\tag{1.2}
$$

2 Results

The minimal possible cost found to meet the daily nutritional quotas with the five selected foods was $6.36. Avocado and Cheese did not have a good price compared to nutritional content, so they were left out of the final result. The optimal diet per day is to eat 1.18 servings of beans, 11.65 servings of rice, and 0.94 servings of spinach. The final amounts of each of the nutrients are given in (2.1).

The final output of the program:

```
Optimal
Foods_avocado  =  0.0
Foods_beans  =  1.1871354
Foods_cheese  =  0.0
Foods_rice  =  11.656146
Foods_spinach  =  0.94240838
6.36434313802436
```

$$Sodium = 658.32$$
$$VitaminC = 90.00$$
$$Protein = 56.00$$
$$VitaminA = 30045.86 \tag{2.1}$$
$$Calories = 2000.00$$
$$SaturatedFat = 0.20$$

3 MENU

1. Breakfast: Eat 5 servings of rice, and sprinkle some beans on top.

2. Lunch: Eat 3 servings of rice, and have half a serving of spinach on the side.

3. Dinner: Add 3-4 servings of rice to a bowl, add one serving of beans and half a serving of spinach. Mix it together! Enjoy.

4. Dessert: None. Sorry.

4 RESOURCES

- United States Department of agriculture - `https://ndb.nal.usda.gov/ndb/`

- Cost Cheese - `http://www.wisconline.com/cgi-bin/aaw_catalog.pl?start=109&end=117&t=ven&ven=125`

- Cost Spinach - `https://www.howmuchisit.org/how-much-does-spinach-cost/`

- Cost Beans - `https://www.amazon.com/365-Everyday-Value-Organic-Black/dp/B074MFZ1NS/ref=sr_1_3_a_it/146-5585447-2072360?ie=UTF8&qid=1523249746&sr=8-3&keywords=organic+black+beans`

- Cost Rice - `https://www.answers.com/Q/How_much_does_one_pound_of_rice_cost`

- Cost Avocado - `https://www.hassavocadoboard.com/retail/volume-and-price-data`

- Average Avocado Size - `https://www.answers.com/Q/What_is_the_weight_of_an_average-sized_avocado`