Methods

Using five foods I regularly eat; I used linear programming to see how many servings I should eat (weekly) to maintain the suggested nutrient in-take (outlined by the US FDA) while minimizing costs. Using PuLP in Python, I set up my decision variables (servings of each food), constraints (nutrient levels), and the objective function (equation to minimize cost). Given that the foods I chose all lack significant values of Vitamin D (that is to say 0), when I first ran the problem, there was no optimal solution. I reran the code without the Vitamin D constraint in order to have an optimal solution. I then added another constraint that I must have at least one serving of each food throughout the week. Finally, I used a LLM (ChatGPT) to look at other ways to solve the problem (ChatGPT recommended code using scipy and matrices rather than equations).

PART 1

Calculations:

- Conversions:
  - Spinach % Conversion for Iron: https://ods.od.nih.gov/factsheets/Iron-HealthProfessional/
  - For a 19-50 year old woman, suggested iron intake is 18mg -> 15%*(18mg) = 2.70mg
  - Spinach % Conversion for Calcium: https://ods.od.nih.gov/factsheets/Calcium-HealthProfessional/
  - For a 19-50 year old woman, suggested iron intake is 1,000mg -> 8%*(1,000mg) = 80mg
  - Spinach Total Carbohydrates: 3 mg = 0.003 g
  - Breakfast Sausage – I eat two rather than 1, all numbers = serving size multiplied by 2
- Cost per serving:
  - Nature Valley Peanut Butter Granola Bars
    - $1.10/serving ($5.49/box of 5, 1 serving = 1 bar)
  - Yogurt
    - $1.18/serving ($6.29/32oz, 1 serving = ¾ cup)
  - Vegetarian Sausages
    - $1.66/meal ($4.99/bag of 6, 1 serving = 1 patty, I normally eat 2)
  - Spinach
    - $0.90/serving ($4.49/5oz, 1 serving = 1oz)
  - Chickpea patties
    - $1.15/serving ($4.59/bag of 4, 1 serving = 1 patty)

PART 2

Decision Variables:

- x1 = servings of yogurt ($1.18/serving)
- x2 = servings of spinach ($0.90/serving)
- x3 = servings of chickpea patty ($1.15/serving)

- x4 = servings of Nature Valley Bar ($1.10/serving)
- x5 = servings of sausage patty ($1.66/serving, serving will refer to TWO patties)

Objective function in standard form:

- Minimize Z = 1.18*x1 + 0.9*x2 + 1.15*x3 + 1.1*x4 + 1.66*x5

Constraints

- Sodium
  - 60*x1 + 65*x2 + 380*x3 + 160*x4 + 460*x5 <= 5000
- Calories/Energy
  - 120*x1 + 20*x2 + 170*x3 + 190*x4 + 160*x5 >= 2000
- Protein
  - 15*x1 + 2*x2 + 9*x3 + 4*x4 + 18*x5 >= 50
- Vitamin D
  - 0*x1 + 0*x2 + 0*x3 + 0*x4 + 0*x5 >= 20
- Calcium
  - 180*x1 + 80*x2 + 20*x3 + 0*x4 + 60*x5 >= 1300
- Iron
  - 0.2*x1 + 2.7*x2 + 1.2*x3 + 0.8*x4 + 1.8*x5 >= 16
- Potassium
  - 240*x1 + 0*x2 + 260*x3 + 100*x4 + 220*x5 >= 4700
- Non negativity Constraints,
  - x1 >= 0, x2 >= 0, x3 >= 0, x4 >= 0, x5 >= 0

In this problem we are trying to minimize the cost for a diet that is made up of five items (Yogurt, Spinach, Chickpea Patty, Nature Valley Bar, and Sausage Patties) while staying within the recommended food guidelines of 5000 mg of Sodium, 2000 Calories (kcal), 50 g of Protein, 20 mcg of Vitamin D, 1300 mg of Calcium, 16 mg of Iron, 4700 mg of Potassium. The above is for DAILY intake. See below for WEEKLY.

Decision Variables:

- x1 = servings of yogurt ($1.18/serving)
- x2 = servings of spinach ($0.90/serving)
- x3 = servings of chickpea patty ($1.15/serving)
- x4 = servings of Nature Valley Bar ($1.10/serving)
- x5 = servings of sausage patty ($1.66/serving, serving will refer to TWO patties)

Objective function in standard form:

- Minimize Z = 1.18*x1 + 0.9*x2 + 1.15*x3 + 1.1*x4 + 1.66*x5

Constraints

- Sodium (mg)
  - 420*x1 + 455*x2 + 2660*x3 + 1120*x4 + 3220*x5 <= 35000
- Calories/Energy (kcal)
  - 840*x1 + 140*x2 + 1190*x3 + 1330*x4 + 120*x5 >= 14000

- Protein (mg)
  - 0.105 * x1 + 0.014 * x2 + 0.063 * x3 + 0.028 * x4 + 0.126 * x5 >= 0.350
- Vitamin D (mg)
  - 0*x1 + 0*x2 + 0*x3 + 0*x4 + 0*x5 >= 140
- Calcium (mg)
  - 1260*x1 + 560*x2 + 140*x3 + 0*x4 + 420*x5 >= 9100
- Iron (mg)
  - 1.4*x1 + 18.9*x2 + 8.4*x3 + 5.6*x4 + 12.6*x5 >= 112
- Potassium (mg)
  - 1680*x1 + 0*x2 + 1820*x3 + 700*x4 + 1540*x5 >= 32900
- Non negativity Constraints,
  - x1 >= 0, x2 >= 0, x3 >= 0, x4 >= 0, x5 >= 0

PART 3

When solving the problem, the foods I included did not have enough (any) vitamin D. I had to remove that constraint in order to get an optimal solution. For a weekly cost of $21.60, I can meet all the criteria by eating six servings of yogurt and 12 chickpea patties.

PART 4

To have at least one serving of each food in my weekly diet, I would have to increase the servings of yogurt from six to seven and reduce chickpea patties from 12 to 10. Total cost would increase by $2.28 (from $21.60 to $23.88).

To add more variety to my diet I would likely add more fruit or other vegetable options. The biggest focus would be on adding something with a lot of vitamin D per serving (like fish or mushrooms). To add a vitamin D rich item to the model, I would collect the nutrition information, convert units to mg as needed, create a new variable (x6) and add the respective components to each constraint (sodium, protein, vitamin D, etc.). Given how lacking my “diet” is, I would set a constraint to have at least two servings of the vitamin D food.

PART 5

I used ChatGPT4 for Part 5 (Link to chat). The LLM was able to set up the problem and different constraints, however, it was unable to actually calculate the different amounts of each food. I was concerned that the lack of Vitamin D would cause issues with the calculations and the agent would return the solution wasn’t possible, however, it was unable to solve the problem (it offered to give me Python code) and advised I need another food if I were to get the necessary levels of vitamin D. I think ChatGPT (or another LLM) could be helpful to set-up the problem or even provide code (since some of the equations were a little tedious and prone to error), but not for solving. There was very little tailoring needed, but I think that was in part due to how comprehensive my prompt was.