Diet Problem Focusing on Environmental Consumption

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ABSTRACT. Human bodies need various types of nutrients each day to make the body function normally, and the ratio and amount of consumption of each nutrient are significant, especially for teenagers. Today, as the earth's resources continue to decline and environmental pollution continues to increase, people are not only considering the taste and nutrition of a food product, but also adding a new factor — environmental impact. Every single product people consume does some harm to the environment in the production, and the most common ones are the release of harmful gasses and the deterioration of soil erosion. As a result of such concerns, many people changed their eating habits. This paper intends to explore the relationship between nutrient content, cost and environmental consumption with the current knowledge about linear programing and diet problems. In the following content, this work is going to establish and analyze a diet problem with a hypothetical background, and use linear programming to calculate a combination of food products that has the minimal impacts on the environment but still fulfills the limitation of nutrients intake and budgets.

Keywords: environmental impact, nutritional requirement, linear programming

1 Introduction

The diet problem was an optimization problem firstly studied in the 1930s and 1940s, and it aimed at providing a healthy diet for the army while minimizing the cost [1]. In the present stage, there are still concerns about food supply and its environmental cost. Since raising poultry produces methane and vegetables can't satisfy the growing needs of students, we decided to study how a diet can not only meet the nutritional requirement of meat and vegetables, but also minimize the environmental impact.

In the work, we collected the nutrition content and quality of each ingredient, searched for the nutrients each student needs everyday, and then made use of python to construct an optimization equation to figure out the best combination.

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2 Diet Problem

2.1 What is a Diet Problem?

Diet problem, as its name suggests, refers to research questions focusing on a set of food items. The general goal of a diet problem is to select a combination of ingredients that will satisfy another set of constraints [2]. The classification of nutritional indicators may change based on different backgrounds. Generally, it includes the number of calories, vitamins, minerals, fats, sodium, and cholesterol. The other commonly considered factors are economic factors including ingredients' costs and financial penalties, as well as environmental assumptions since they are most directly related [3]. Diet problem is a very typical linear problem as its goal is to find an optimal solution that fits all constraints identified above.

2.2 Diet problem in this work

In this hypothetical situation, the goal is to find an optimal solution for providing food for 1,000 high school students and minimizing the environmental damages while meeting the standard amounts of the nutrients and within limited costs. Specifically, the budget factors consider food prices, taxes, and feed cost. Environmental factors include carbon emissions, methane emissions, land and water consumptions, etc. [4]. Finally, the nutritional factors mainly contain calories, protein, carbohydrate, and fat. Because the hypothetical situation is in a high school, the data being used is aimed at teenagers, which suggests that the proportion of nutrients required by high school students is 60% carbohydrate, 25% fat, 15% protein. As the data suggests boys should consume 2400~2900 kcal per day and girls should consume 2200~2400kcal per day, the work takes the combined range of calorie consumption from 2200 to 2900 kcal. The specific number of nutrients required is listed in Table 1.

Table 1. Nutrient Requirement [5 - 8]

Nutrient	**Requirement**
Calories	2200-2900 calories
Nutrient	**Requirement**
Protein	55-75 grams
Carbohydrate	220-300 grams
Fat	90-125 grams

2.3 Data

After establishing the variables, the specific quantity of every nutrition contained in 100 grams of food is needed in order to calculate the minimum allowable amount of a type of food. The data needed are shown in Table 2.

Table 2. Price and Nutrition of Products [9]

Product	Carbohy-drate/100g	Total fat/100g	Pro-tein/100g	Calo-ries/100g	Price$/1b
Broccoli	9.56	0.17	1.61	43	3.49
Onions	7.9	0.2	1.2	36	2.49
Carrot	9.58	0.24	0.93	41	2.49
Cabbage	3.9	0.5	2.1	27	1.29
Cucumber	1.5	0.1	0.7	10	1.29
Apple	12	0.1	0.4	47	4.99
Orange	14	0.2	1.8	60	1.67
Banana	22	0.2	11.4	89	0.99
White rice	76.6	0.8	6.2	351	1.30
Beef	0	5.1	32	175	9.99
Chicken	0	7.5	27	177	5.49
Pork	0	5.1	35	185	7.49
Salmon	0	11	20	180	14.99

In addition to these regular data, data of environmental impact is needed, which is the greenhouse gas emissions specifically in this problem, as shown in Table 3:

Table 3. Greenhouse Gas Emission [10]

Product	Greenhouse gas/100kg
Lamb & mutton	39.72
Beef (dairy herd)	33.3
Prawns	26.78
Cheese	23.88
Fish	13.63
Pig meat	12.31
Poultry meat	9.87
Eggs	4.67
Rice	4.45
Banana	0.86
Apple	0.43

3 Calculation [11]

3.1 Sets

$F = set\ of\ foods$
$N = set\ of\ nutrients$

3.2 Parameters

$a\_ij = amount\ of\ nutrient\ j\ in\ food\ i$
$c\_i\ =\ cost\ per\ serving\ of\ food$
$F\_min\_i = minimum\ number\ of\ required\ servings\ of\ food\ i$
$F\_max\_i = maximum\ allowable\ number\ of\ servings\ of\ food\ i$
$N\_min\_j = minimum\ required\ level\ of\ nutrient$
$N\_max\_j = maximum\ allowable\ level\ of\ nutrient$

3.3 Variables

$F\_i\_impact = impact\ on\ environment$

3.4 Constraints

$x\_i = number\ of\ servings\ of\ food\ i\ to\ purchase/consume$
budgets and the lowest bond for nutrition

3.5 Procedure

Firstly, plug in the nutrition, price, and environmental consumption data of twenty-five food products, including eight vegetables, five fruits, eight meats and four staples. Then, the lowest requirement for each nutrient listed in the table above as well as the highest bond of the product's costs are set in python, and type down the calculation code in python to get the best combination that minimizes the environmental impacts while meeting both nutritional and budgeting constraints.

3.6 Results

The best combination:

Protein: duck 100g, bacon 100g

Dietary fiber: cabbage 150g, corn 150g, apple 100g, orange 300g Carbohydrate: bread 100g, noodle 800g

Total cost: 107.9 dollars

4 Conclusion

The final combination of food products calculated contains 11.11% of meat, which is the main resource of protein; 38.89% of fruit and vegetables, which is the main resource of dietary fiber; and 50% of staples, the main resource of carbohydrate, in mass, which in total costs 107.9 dollars. Such a combination can minimize the environmental impact while providing the necessary nutrition and fitting in the budget. The result is reasonable since it can be seen from the data of greenhouse gas emissions caused by food sources that farmed food, such as beef and mutton, is the most harmful resource to the environment, causing pollution far more than those made by plants and grains.

Therefore, in order to restrain the impact of food on the ecosystem, people can consume a relatively large amount of fruit and vegetables in daily lives since it will not cause much consequence to the earth. On the contrary, people's daily intake of meat can be reduced accordingly since meat products have the greatest environmental damages.

Vegetarianism, therefore, is an eco-friendly eating habit under the conclusion of this study.

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