



The Optimal Diet Plan

ABSTRACT

The project aims at providing a wholesome diet plan for a dietitian's clients. Uses excel solver to setting different objectives and constraints for various diet plans such as Paleo diet, Vegan diet, Muscle gain and weight loss diet plan.

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OSCM6350 Prescriptive Analysis

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Background Of The Project

Researchers suggest that rapid weight loss without considering a balanced diet can lead to slow metabolism, leading to future weight gain. Crash diets would also lead to weaken immune system, increase risk of dehydration and cardiac stress and other problems. Maintaining recommended nutrient level on your diet is very vital. Most of the diets fail in the long run, resulting in gaining back the lost weight.

Generally, diet plans only focus on the macronutrient's proportions such as carbohydrates, fat and protein. Inclusiveness of both micro and macro-nutrients in all three meals is very important for a healthy lifestyle.

As an effort to ease this situation, this project aims at providing a wholesome meal making dieting effective in reducing weight and thus provide effective results in the long run.

Objectives Of The Project

The objective of the project is to improve the overall nutrient intake of an individual while also taking food preferences of the clients into consideration. This is achieved by customizing the food menu i.e., the raw data input for the excel solver. The diet plan is set in such a way that it not only includes all the nutrients, exactly at the level recommended by USDA but also maintains the right about of calorie deficit to achieve the desired weight.

Target And Expected Output Of The Project

General features of the project are listed below.

Expected goals which will be attained after the project completion

1. Goal of the proposed plan
To provide a successful meal plan for clients that includes all nutrients while keeping in mind the calorie intake for weight loss/muscle gain.
2. Goal which will be attained by utilizing the proposed plan
To achieve the target weight with no side effects or health hazards caused by lack of nutrients. Helps to maintain the lost weight in the long run.

Outputs

1. The client receives a meal plan as per his/her type of diet plan
2. The plan includes the food, quantity to be consumed, how many times it must be consumed per day
3. The price of the meal can also be determined which helps the client not exceed his/her food budget.

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Beneficiaries

Clients aiming to reduce weight by following paleo or vegan diet. Clients who focus on muscle gain consuming only lean meat. The constraints of the solver can be adjusted as per the BMI of the client and the data set can be adjusted as per the client's food preference and availability.

Project Activity Flow

The project activity consists of the following four components

1. Improve the raw data quality by data cleaning i.e., Filter unwanted outliers, structural errors, handle missing data, remove duplicate and irrelevant observation.
2. Identify deficit nutrients in a conventional diet plan and set them as the objective for the diet plan. i.e., vegan diets are low in protein and vitamin B12 intake.
3. Set the upper limit and lower limit constraints as per the nutrient recommended by the USDA.
4. Test run the excel solver and find improvements in the process by setting additional constraints.
5. Review the results and the feasibility reports to check if all constraints are fulfilled or violated.
6. Consolidate the output to step up a meal plan.

Mathematical Implementation

The Diet Problem is formulated mathematically using linear programming problem as shown below.

Sets

F = set of foods

N = set of nutrients

Parameters

a_{ij} = amount of nutrient content j in food i , $\forall i \in F \forall i \in F, \forall j \in N \forall j \in N$

c_i = calories per serving of food i , $\forall i \in F \forall i \in F$

$F_{\min i}$ = minimum number of required servings of food i , $\forall i \in F \forall i \in F$

$F_{\max i}$ = maximum allowable number of servings of food i , $\forall i \in F \forall i \in F$

$N_{\min j}$ = minimum required level of nutrient j , $\forall j \in N \forall j \in N$

$N_{\max j}$ = maximum allowable level of nutrient j , $\forall j \in N \forall j \in N$

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Variables

x_i = number of food servings i to purchase/consume, $\forall i \in F$

Objective Function: Minimize/maximize the total calorie intake of the food

Minimize $\sum_{i \in F} c_i x_i$

Constraint Set 1: For each nutrient necessary for the diet $j \in N$, at least meet the minimum required level.

$$\sum_{i \in F} a_{ij} x_i \geq N_{minj}, \forall j \in N$$

Constraint Set 2: For each nutrient necessary for the diet $j \in N$, do not exceed the maximum allowable level.

$$\sum_{i \in F} a_{ij} x_i \leq N_{maxj}, \forall j \in N$$

Constraint Set 3: For each food on the food menu $i \in F$, select at least the minimum required number of servings.

$$x_i \geq F_{mini}, \forall i \in F$$

Constraint Set 4: For each food on the food menu $i \in F$, do not exceed the maximum allowable number of servings.

$$x_i \leq F_{maxi}, \forall i \in F$$

Interpreting The Solution

In this project, there are two main constraints taken into consideration. It bounds on the minimum and maximum allowable number of servings for each food type and the allowable level of nutrients for each type of nutrient according to the USDA recommendations.

Implementation Of The Project

A normal human being must consume at least 2000 calories to maintain his current weight. Basically, a calorie deficit i.e., consuming less than 2000 calories will result in weight loss and a calorie surplus i.e., consuming more than 2000 calories would result in weight gain. This makes dieting easily achievable, but that's not where it all ends. Consuming right amount of both macro and micronutrient will help maintain the results in the long run.

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Vegan Diet Plan

1. Objective function

Maximize the protein intake and consume the right amount of vitamin B12

$$\text{MAXIMIZE } \sum_{i \in F} p_i x_i \sum_{i \in F} v_i x_i$$

x_i = number of food servings

p_i = Protein per serving of food i , $\forall i \in F$

2. Constraints

$$\begin{aligned} & \$T\$2:\$T\$132 \leq 3 \\ & \$T\$2:\$T\$132 \geq 0 \\ & \$X\$11:\$X\$19 \leq \$Z\$11:\$Z\$19 \\ & \$X\$22:\$X\$30 \geq \$Z\$22:\$Z\$30 \end{aligned}$$

Constraint 1 : each food item on the menu cannot be selected more than 3 times. The number 3 is taken considering a client having a vegan diet consumes 3 meals a day

For each food on the food menu $i \in F$, do not exceed the maximum allowable number of servings.

$$x_i \leq F_{max_i}, \forall i \in F$$

Constraint 2: This constraint is a non-negativity constraint and determines the minimum number of times a food item can be chosen.

For each food on the food menu $i \in F$, select at least the minimum required number of servings.

$$x_i \geq F_{min_i}, \forall i \in F$$

Constraint 3 : This constraint sends the upper bound for all the necessary nutrients micro and macro nutrients.

For each nutrient necessary for the diet $j \in N$, do not exceed the maximum allowable level.

$$\sum_{i \in F} F_{aij} x_i \leq N_{max_j}, \forall j \in N$$

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upperlimit				
Cholesterol	112.84615	<=	184	mg
Total Fat	48	<=	48	g
Carbs	171.77312	<=	203	g
Dietary Fiber	7.5	<=	7.5	g
protien	45.481543	<=	56	g
vit b12	0.8	<=	3	mg
Calorie	1200	<=	2000	cal
Iron	13	<=	13	mg
Sodium	2585	<=	2585	mg

Constraint 4 : This constraint sends the lower bound for all the necessary nutrients micro and macro nutrients.

For each nutrient necessary for the diet $j \in N, j \in N$, at least meet the minimum required level.

$$\sum_{i \in F} a_{ij} x_i \geq N_{minj}, \forall j \in N, \sum_{i \in F} a_{ij} x_i \geq N_{minj}, \forall j \in N$$

lowerlimit				
Cholesterol	112.84615	>=	91	mg
Total Fat	48	>=	17.09	g
Carbs	171.77312	>=	45.8	g
Dietary Fiber	7.5	>=	4	g
protien	45.481543	>=	18.5	g
vit b12	0.8	>=	0.8	mg
Calorie	1200	>=	1200	cal
iron	13	>=	5.2	mg
Sodium	2585	>=	544	mg

The Optimal Diet Plan

Objective							
Protien	Max	45.481543					
Constraints							
upperlimit							
Cholesterol	112.84615	<=	184	mg			
Total Fat	48	<=	48	g			
Carbs	171.77312	<=	203	g			
Dietary Fiber	7.5	<=	7.5	g			
protien	45.481543	<=	56	g			
vit b12	0.8	<=	3	mg			
Calorie	1200	<=	2000	cal			
Iron	13	<=	13	mg			
Sodium	2585	<=	2585	mg			
lowerlimit							
Cholesterol	112.84615	>=	91	mg			
Total Fat	48	>=	17.09	g			
Carbs	171.77312	>=	45.8	g			
Dietary Fiber	7.5	>=	4	g			
protien	45.481543	>=	18.5	g			
vit b12	0.8	>=	0.8	mg			
Calorie	1200	>=	1200	cal			
iron	13	>=	5.2	mg			
Sodium	2585	>=	544	mg			
All serving sizes are in 100 grams. Use the serving size conversion weights at the end of the file to convert values.							
For example to convert to an ounce (28.4g) multiply each value by 0.284							

NOTE: The constraints for the nutrient intake for all four plans (vegan, Paleo, weight loss, muscle gain) remains to be the same. Whereas the objective for each of the diet plan varies. Keeping this in mind lets discuss on the objectives for the other three plans.

Paleo Diet Plan

While paleo diet focuses on reducing weight by consuming lean meat. They consume good about of protein, fat and other macronutrients. According to USDA, paleo diet misses on calcium and vitamin D in their food. Considering this issue, our objective for paleo diet is maximizing the calcium intake level and maintaining it in the recommended levels.

1. Objective function

Maximize the calcium intake and consume the right amount of Calcium

$$\text{MAXIMIZE } \sum_{i \in F} p_i x_i \sum_{i \in F} p_i x_i$$

x_i = number of food servings; c_i = calcium per serving of food i , $\forall i \in F$

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Objective							
Calcium	Max		418				
Constraints							
upperlimit							
Cholesterol	153.965361	<=	184	mg			
Total Fat	48	<=	48	g			
Carbs	135.95865	<=	203	g			
Dietary Fiber	4.87833123	<=	7.5	g			
protien	56	<=	56	g			
calcium	418	<=	418			418	
Calorie	1200	<=	2000	cal			
Iron	7.44933211	<=	13	mg			
Sodium	2488.31042	<=	2585	mg			
lowerlimit							
Cholesterol	153.965361	>=	91	mg			
Total Fat	48	>=	17.09	g			
Carbs	135.95865	>=	45.8	g			
Dietary Fiber	4.87833123	>=	4	g			
protien	56	>=	18.5	g			
Calorie	1200	>=	1200	cal			
iron	7.44933211	>=	5.2	mg			
Sodium	2488.31042	>=	544	mg			

All serving sizes are in 100 grams. Use the serving size conversion weights at the end of the file to convert values.
 For example to convert to an ounce (28.4g) multiply each value by 0.284

Weight Loss Diet Plan

1. Objective function

Minimize the total calorie intake of the food. As mentioned earlier, a calorie deficit would help to reduce obesity. The calorie intake can be adjusted in the constraints as per BMI of the client.

$$\text{Minimize } \sum_{i \in F} c_i x_i$$

x_i = number of food servings; c_i = calorie per serving of food i , $\forall i \in F$

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Muscle Gain Diet Plan

1. Objective function

Maximize the calorie intake and consume the right amount of calorie recommended to increase the weight. Increasing weight by consuming less fat and more protein is necessary for muscle gain. If not, surplus calorie would result in obesity.

Maximize $\sum_{i \in F} c_i x_i - \sum_{i \in F} c_i x_i$

x_i = number of food servings; c_i = calorie per serving of food i , $\forall i \in F$

Result And Evaluation Of The Project

The excel solver run the constraints and found an optimal solution for all four diet plans. All constraints and optimality conditions being satisfied.

We need to understand that each food item's quantity is 100 grams per serving. The solver arrives at a list of food that can be consumed per day and not per meal. The solver is set in such a way that same food item is not chosen more than 3 times.

Vegan diet

Vegan Diet												
name	Food Group	Calories	Fat (g)	Protein (g)	Carbohydrate (g)	Fiber (g)	Cholesterol (mg)	Iron, Fe (mg)	Vitamin B-12 (mcg)	Omega 3s (mg)	Sodium (mg)	Decision variable
Cremini Mushrooms	Vegetables	22	0.1	2.5	4.3	0.6	0	0.4	0.1	0	6	3.0
Cooked Soybean Sprouts	Vegetables	81	4.45	8.47	6.53	0.8	0	1.31	0	296	10	0.7
Arrowhead Cooked Boiled Drained With Salt	Vegetables	78	0.1	4.49	16.14	0	0	1.21	0	0	254	3
Cooked Purslane	Vegetables	24.7	0.19	1.49	3.55	0	0	0.77	0	0	44	3.0
Celeriac Cooked Boiled Drained With Salt	Vegetables	27	0.19	0.96	5.9	0	0	0.43	0	0	297	2.25
Borage Cooked Boiled Drained Without Salt	Vegetables	25	0.81	2.09	3.55	0	0	3.64	0	0	88	0.24
Cabbage Creamed	Vegetables	79	4.86	2.44	7.16	1.1	3	0.24	0.13	75	221	0.62
Creamed Christophine Puerto Rican Style	Vegetables	141	4.09	2.21	25.07	1.5	37	0.59	0.14	4	280	3.0
Dried Pilinuts	Nuts and Seeds	719	79.55	10.8	3.98	0	0	3.53	0	0	3	0.3
Nuts Coconut Meat Dried (Desiccated) Creamed	Nuts and Seeds	684	69.1	5.3	21.5	0	0	3.36	0	0	37	0.02
total		1201	45.6	45.5	172	7.54	113	13	0.8	266	2587	

This chart implies that client can consume 300 grams of cremini mushrooms (i.e.) $3 \times 100 = 300$ grams. This is because all servings are in 100 grams. And the decision variable says 3. Which implies the dish can be consumed thrice per day.

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The objective is to maximize the protein content in food and to achieve the desired amount of vitamin B12. The recommended quantities of proteins and vitamins were hard to include in any conventional vegan diet.

Paleo Diet

Paleo diet includes high quality of protein and a powerhouse of nutrient in it.

Paleo Diet																
name	Food Group	Calories	Fat (g)	Protein (g)	Carbohydrate (g)	Fiber (g)	Cholesterol (mg)	Calcium (mg)	Iron, Fe (mg)	Vitamin B-12 (mcg)	Vitamin D (mcg)	Omega 3s (mg)	Sodium (mg)	Zinc, Zn (mg)	Decision Variable	
Chicken Drumstick Grilled Without Sauce Skin Not Eaten	Meats	330	25.63	16.86	8.56	0	98	682	0.26	1.33	2.5	161	1284	2.31	0.45	
Pork Chop Battered Fried Lean Only Eaten	Meats	246	10.57	23.67	12.84	0.4	68	37	1.14	0.46	0.3	2	427	1.64	0.4	
Shrimp Dried	Fish	253	3.44	51.7	0	0	638	367	5.39	1.87	0	1530	2203	4.96	0.01	
Beef And Rice No Sauce	Meats	145	5	7.27	17.23	0.2	17	8	1.21	0.31	0	4	312	1.26	3	
Fish And Rice With Tomato-Based Sauce	Fish	135	5.12	5.41	16.53	0.7	9	12	1.02	0.17	0.2	27	310	0.42	2.45	
Barley Soup Sweet With Or Without Nuts Asian Style	Soups and Sauces	61	1.55	1.01	11.57	0.8	0	13	0.22	0	0	198	4	0.16	3	
total		1200	48	56	136	4.88	154	418	7.45	2.16	1.73	768	2488	7.06		

All constraints were met and the objective of maximizing calcium is achieved. While concentrating in a protein rich diet, often calcium and other necessary vitamins that can be gotten only from dairy products and vegetables are missed. Here we could see the recommended amount of all nutrients including calcium and vitamins are included in this balanced diet.

Fat loss diet

This diet plan is quite interesting than other plans. A vegan or a paleo diet has many dietary constraints such as no meat or no dairy products. But a regular fat loss diet has no such dietary restrictions and it's a way where a client can eat all his favorite foods and still reduce body weight. If noticed the solver result also includes restaurant foods, sweet and baked foods. The nutrient recommendation and weight loss is also taken into consideration.

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fat loss																
name	Food Group	Calories	Fat (g)	Protein (g)	Carbohydrate (g)	Fiber (g)	Cholesterol (mg)	Calcium (mg)	Iron, Fe (mg)	Vitamin A, RAE (mcg)	Vitamin C (mg)	Vitamin B-12 (mcg)	Vitamin D (mcg)	Sodium (mg)	Zinc, Zn (mg)	decision variable
Gelatin Snacks	Sweets	139	0	2.84	33	0	0	3	0.05	0	0	0	0	172	0	3
Granola Homemade	Breakfast Cereals	489	24.31	13.67	53.88	8.9	0	76	3.95	1	1.2	0	0	26	4.17	0.36
Milk Imitation Non-Soy	Dairy and Egg Products	46	2	1.6	5.3	0	0	82	0.1	61	0	0	1.1	55	0.1	3
Restaurant Chinese Kung Pao Chicken	Restaurant Foods	129	6.98	9.76	6.87	1.5	26	20	0.76	65	7.1	0.11	0	402	0.74	2.56
Seafood Stew With Potatoes And Vegetables Including Corn	Fish	146	3.69	3.2	24.92	0.5	8	90	0.23	0	0	0.08	0	106	0.5	0.85
Shrimp Curry	Fish	59	1.55	5.22	5.53	0	25	44	5.78	8	4.7	16.2	0	178	37.92	0.16
Chicken Breast Oven-Roasted Fat-Free Sliced	meats	84	2.54	15.21	0.03	0	369	8	6.6	61	0	50.37	0.1	168	1.81	0.04
total		1200	36.2	47.4	174	7.5	91	418	5.2	353	19.3	4.82	3.3	1844	10.3	

Muscle gain

The composition of diets for body builders should be 55-60% carbohydrate, 25-30% protein and 15-20% of fat, for both the off-season and pre-contest phases. Keeping this in mind the following diet plan is structured.

Our diet plan consists of 60% carbs 25 % protein and 14% total fat. This is very appropriate for lean muscle building. Most of the traditional diet plan concentrate on these macro nutrients but miss out on the micronutrient factors. Which leads to weaken immune system and other chronic diseases. The excel solver results has the right mixture of both micro as well as macro nutrients in its weight loss plan.

Muscle gain															
Name	Serving	Price/ Serving (\$)	Calories(cal)	Cholesterol(mg)	Total_Fat(g)	Sodium(mg)	Carbohydrates(g)	Dietary_Fiber(g)	Protein(g)	Vit_A(IU)	Vit_C(IU)	Calcium(mg)	Iron(mg)	decision variable	
Lettuce, Iceberg,Raw	1 Leaf	0.02	2.6	0	0	1.8	0.4	0.3	0.2	66	0.8	3.8	0.1	0.558	
Corn Flakes, Kellogg'S	1 Oz	0.28	110.5	0	0.1	290.5	24.5	0.7	2.3	1252	15.1	0.9	1.8	1.82	
Rice Krispies	1 Oz	0.32	112.2	0	0.2	340.8	24.8	0.4	1.9	1252	15.1	4	1.8	3	
Couscous	1/2 Cup	0.39	100.8	0	0.1	4.5	20.9	1.3	3.4	0	0	7.2	0.3	3	
Macaroni, cooked	1/2 Cup	0.17	98.7	0	0.5	0.7	19.8	0.9	3.3	0	0	4.9	1	1.065	
Pork	4 Oz	0.81	710.8	105.1	72.2	38.4	0	0	13.8	14.7	0	59.9	0.4	0.526	
Sardines in Oil	2 Sardines	0.45	49.9	34.1	2.7	121.2	0	0	5.9	53.8	0	91.7	0.7	1.584	
White Tuna in Water	3 Oz	0.69	115.6	35.7	2.1	333.2	0	0	22.7	68	0	3.4	0.5	1.969	
total			1627	180	48	2434	203	7.5	85	6299	73.2	226	13		

lean muscle mass building		
carbs	203	60%
protein	85	25%
total fat	48	14%
	336	100%

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Conclusion and future Project Recommendations

This project focuses on intaking the right quantity of macro and micronutrients while striving to reduce body weight. This plan can be modified easily for other BMI or any food preferences of clients.

Future projects can be done based on this diet plan using linear programming on excel Diet plan to formulate a balanced diet for a low-income person using price as the main objective. Many governments in low-income countries can formulated diet plans to eradicate poverty and death caused by starvation. Diet plans for army men and women can be formulated. Dietary plan for patients such as cancer patients who have plenty of dietary restrictions can also be effectively created at a given budget. The scope for this project to grow in various fields is tremendous and could be help millions of people in suffering.

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