Foods optimized for population - Documentation

Introduction

Everyone's dream is to live a Healthy and Happy life. A healthy life can be achieved by consuming healthy foods to meet the daily nutrients. This tool helps to arrive at a healthy optimal diet plan based on your food preferences using a linear optimization technique. It is developed to meet the daily nutrient recommendations of the healthy individual as suggested by the Indian Council of Medical Research-National Institute of Nutrition (ICMR-NIN 2020)[1]. A total of Eighteen dietary nutrients were considered for optimization in the daily food intake. These were Energy (kcal), Protein (g), Fat (g), Carbohydrate (g), Dietary Fiber (g), Calcium (mg), Zinc (mg), Iron (mg), Magnesium (mg), Iodine (µg), Vitamin A (µg), Folate (µg), Vitamin B12 (µg), Vitamin B1 (mg), Vitamin B2 (mg), Vitamin B3 (mg), Vitamin B6 (mg) and Vitamin C (mg) has been optimally met with this tool. A healthy diet is not only meeting the Nutrients but also equal importance in having diet diversity. Over 120 food items have been considered in the tool to maintain the preferences and the same has been categorized into 12 food groups to maintain the diversity in diets. A separate diet has been considered for foods like Milk products, Egg, and Non-Veg. Four different diets have been considered to categorize animal foods such as Diet1 (Vegetarian), Diet2 (Lacto-Vegetarian), Diet3 (Lacto-ovo-Vegetarian), and Diet4 (Non-Vegetarian). This will be helpful for people to select the best diets by comparing the cost of the diet and the quantity to be consumed across diets. The nutrient recommendations vary based on the age groups so separate optimization for each of the age groups has been considered

This tool helps the State and district officials and policymakers to understand the optimal diet pattern of their people based on their intake habits. It will be helpful to make policies related to Nutrition and Foods like Public Distribution System (PDS). Also, State and District officials can plan and suggest people with multiple optimal diet plans based on their local consumption patterns and make their life healthy. The tool can be used as a reference to arrive at decisions regarding the food item combinations that can be used in a hot cooked meal. Given that children across the States have varying preferences of food items, the tool can be utilized to come up with the main ingredients that can be used in their midday meal programs. The same can also be considered to decide the type of special food to be given for all the beneficiaries across States.

Datasets used

Population projection – The population count of the state and district has been projected from 2011 census data using the State specific Birth ratios, Sex ratios, Survival rates, Fertility rates, and death ratios [2,6]. The newly formed districts and states will have the default count as one for all age groups.

Food choices – The choice of foods for the first set of optimal diets has been obtained using the NSSO data of most consumed food items of the State/District and by Area Production and Yield Statistics (APY) for most produced food items of that State/District [3,4].

Food price – The State specific market price has been taken from the Agmarknet website for all the ingredients [5]. The option to update the State specific Market price is available for login users.

Wages data – The state-specific average wages information was considered from the RBI 2020-21 handbook

Nutrient recommendation – The Age-specific nutrient recommendation for the health population was taken from the ICMR-NIN 2020 [1]**.** The nutrient recommendations vary based on the age groups so separate optimization for each of the age groups has been considered

Optimization model

Method

The method we used here is the Linear programming problem. It is an optimization method for a linear objective function and a system of linear inequalities or equations. Linear inequalities or equations are known as **constraints**. The quantity which needs to be maximized or minimized (optimized) is reflected by the **objective function**. The fundamental objective of the linear programming model is to look for the values of the variables that optimize (maximize or minimize) the objective function.

Objective function

This function is expressed as a linear function, and it describes the quantity that needs optimization. Our objective is to minimize the cost of the diet which is written below

$$Minimize\ Total\ Cost = \min\{\ \sum_{i=1}^{I} Q_i \times C_i\ \}$$

where Q_i is the quantity of item i and C_i is the cost per unit of raw food item i.

Constraints

These are the limitations set on the main objective function. These limitations must be represented in mathematical form. The major constraint is to meet the age-specific nutrition recommendations for a healthy population. **Diet1 (Vegetarian)** does not consider Vitamin B12. Also, it considers half the requirement of Vitamin B2 and Calcium. **Diet2 (Lacto-Vegetarian)** and **Diet3 (Lacto-ovo-Vegetarian)** consider half the daily requirement of VB2 if Paneer is the only Milk product. Also, it does not consider VB12 if Curd is the only Milk product. **Diet4 (Non-Vegetarian)** considers half the daily requirement of VB12 if Curd, Chicken, and Egg are the only Animal foods. Also, it does not consider VB12 if Curd and Chicken are the only Animal foods.

The daily Estimated Average Requirement of nutrients (EAR) and the daily Tolerable Upper Limit of nutrient intake (TUL) were used as the constraints of the daily minimum and maximum nutrient intake. This meant that the proposed optimized diet had to necessarily meet the daily EAR of all the nutrients listed while not exceeding the TUL of any of the listed nutrients.

Fat is a minimum of 35% of Energy and a maximum of 40% of Energy

The Fat energy ratio is calculated as:

Fat (g) ≥ Energy (kcal) / 9 *0.35 | Fat (g) ≤ Energy (kcal) / 9 *0.40

Protein is a minimum of 10% of Energy and a maximum of 15% Energy

The Protein Energy ratio is calculated as:

Protein (g) ≥ Energy (kcal) / 4 *0.10 | Protein (g) ≤ Energy (kcal) / 4 *0.15

Carbohydrate is a maximum of 65% Energy and the Carbohydrate Energy ratio is calculated as:

Carbohydrate (g) ≤ Energy (kcal) / 4 *0.65

Protein digestibility factors are considered while optimizing for protein requirements [7,8].

Other constraints such as the Minimum no of food items in the food group to maintain diet diversity, Sugar Energy ratio has been considered from the ICMR-NIN to make a healthy diet. Also, we have assumed that the recommendation of Iodine is met only from salt

Optimal diets

Using the linear programming method, we can get the optimal cost diet plan which meets the nutrition requirements by satisfying all the constraints. The optimal diet has been displayed in various methods for easy understanding of users. The user can optimize for all age groups and all four diets at a time and compare the optimal cost and the intake quantity across diets. The ratio of the Nutrition intake to the recommendation has been displayed in the Radar chart. The pie chart tells the percentage proportion of each of the food groups in a daily diet. Optimal cost calculations give the cost needed for the individual and the population to meet the daily nutrients.

Data Reference

1. https://www.nin.res.in/RDA_Full_Report_2020.html
2. https://censusindia.gov.in/census.website/data/census-tables
3. http://microdata.gov.in/nada43/index.php/catalog/CEXP
4. https://aps.dac.gov.in/Home.aspx?ReturnUrl=%2f
5. https://agmarknet.gov.in/

Paper Reference

6. https://drive.google.com/file/d/1LTzC1cq6m4pBt134jIPT8z3Na8y8MN_4/view
7. https://academic.oup.com/ajcn/article/109/5/1319/5421478,
8. https://academic.oup.com/ajcn/article/110/4/873/5543217?login=true

IFCT Food codes

Food Name	Food Group	Food code
Bajra	Cereals and Millets	A003
Barley	Cereals and Millets	A004
Jowar	Cereals and Millets	A005
Maize and Products	Cereals and Millets	A007
Ragi	Cereals and Millets	A010
Rice flakes	Cereals and Millets	A011
Rice puffed	Cereals and Millets	A012
Rice	Cereals and Millets	A015
Refined wheat flour	Cereals and Millets	A018
Wheat flour atta	Cereals and Millets	A019
Egg	Egg	M001
Apple	Fruits	E004
Apricot	Fruits	E005
Bael	Fruits	E008
Banana	Fruits	E012
Berries	Fruits	E013
Cherry	Fruits	E014
Custard Apple	Fruits	E016
Dates	Fruits	E019
Fig	Fruits	E020
Amla	Fruits	E021
Grapes (Green)	Fruits	E023
Guava	Fruits	E028
Jack Fruit	Fruits	E030
Jamun	Fruits	E031
Citrus	Fruits	E033
Lime	Fruits	E033
Lime-Lemon (Sweet)	Fruits	E034
Litchi	Fruits	E035
Mango	Fruits	E036
Musk Melon	Fruits	E045
Mandarin Orange	Fruits	E047
Orange	Fruits	E047
Sweet Orange	Fruits	E047
Papaya	Fruits	E049
Peach	Fruits	E050
Pear	Fruits	E051
Pineapple	Fruits	E053
Plum	Fruits	E054
Pomegranate	Fruits	E055
Raisin (Kishmish, Monacca Etc)	Fruits	E057
Sapota	Fruits	E060
Strawberry	Fruits	E063
Watermelon	Fruits	E066

Ber	Fruits	E068
Persimon	Fruits	-
Dragon Fruit	Fruits	USDA
Kiwi	Fruits	USDA
Mulberry	Fruits	USDA
Amaranth leaves (Cholai)	Green Leafy Vegetables	C003
Bathua leaves	Green Leafy Vegetables	C008
Colocasia leaves	Green Leafy Vegetables	C018
Drumstick leaves (Sajina/Muringa)	Green Leafy Vegetables	C019
Fenugreek leaves (Methi)	Green Leafy Vegetables	C020
Mustard leaves (Sarson)	Green Leafy Vegetables	C026
Spinach (Palak)	Green Leafy Vegetables	C033
Plantain (Green)	Green Leafy Vegetables	D063
Green Coriander	Green Leafy Vegetables	G009
Curry leaves	Green Leafy Vegetables	G010
Mint	Green Leafy Vegetables	G016
Milk Buffalo	Milk products	L001
Milk cow	Milk products	L002
Paneer	Milk products	L003
Curd	Milk products	-
Chicken	Non-Veg	N003
Goat Meat /Mutton	Non-Veg	O002
Beef / Buffalo Meat	Non-Veg	O026
Pork	Non-Veg	O049
Fish, Prawn	Non-Veg	S009
Singara (Water chestnut)	Nuts	F016
Almond	Nuts	H001
Cashew Nut	Nuts	H005
Coconut Green	Nuts	H007
Groundnut	Nuts	H012
Walnut	Nuts	H021
Butter	Oil	-
Coconut Oil	Oil	T001
Edible Oil	Oil	T003
Groundnut - Oil	Oil	T005
Mustard Oil	Oil	T006
Refined Oil [Sunflower, Soyabean, Saffola, Etc]	Oil	T010
Ghee	Oil	T013
Vanaspati, Margarine	Oil	T014
Bengal gram dal (Channa dal)	Pulse	B001
Bengal gram flour	Pulse	B001
Bengal gram whole	Pulse	B002
Black gram	Pulse	B004
Cowpea (Lobia)	Pulse	B005
Green gram dal (Moong)	Pulse	B010
Green gram whole (Moong)	Pulse	B011
Horse Gram	Pulse	B012
Khesari	Pulse	B013
Lentil (Masoor dal)	Pulse	B013
Moth Bean	Pulse	B016
Peas dry (Matar)	Pulse	B017

Rajma	Pulse	B020
Red gram dal (Arhar / Tur)	Pulse	B021
Beetroot	Roots and Tubers	F001
Carrot	Roots and Tubers	F002
Potato	Roots and Tubers	F007
Radish	Roots and Tubers	F010
Sweet Potato	Roots and Tubers	F013
Tapioca	Roots and Tubers	F015
Elephant Yam	Roots and Tubers	F017
Yam	Roots and Tubers	F018
Salt	Salt	-
Tamarind	Spices	E064
Green Chillies	Spices	G008
Curry Powder	Spices	G010
Garlic	Spices	G012
Ginger	Spices	G014
Dry Chillies	Spices	G022
Black Pepper	Spices	G031
Turmeric	Spices	G033
Jaggery	Sugar	I001
Sugar	Sugar	-
Cabbage	Vegetables	C015
Ash gourd	Vegetables	D001
Beans	Vegetables	D003
Bitter Gourd	Vegetables	D006
Bottle Gourd	Vegetables	D007
Brinjal	Vegetables	D031
Capsicum	Vegetables	D033
Cauliflower	Vegetables	D036
Cucumber	Vegetables	D043
Drum Stick	Vegetables	D046
Turnip	Vegetables	D054
Lady's finger	Vegetables	D056
Onion	Vegetables	D058
Pointed gourd	Vegetables	D060
Green Peas	Vegetables	D061
Pumpkin	Vegetables	D066
Ridge Gourd	Vegetables	D068
Snake gourd	Vegetables	D070
Tomato	Vegetables	D076
Mushroom	Vegetables	J001
Olive	Vegetables	USDA