MS Nutrition
La solution quantitative

How linear programming can help improve diets and foods

Cost Action FoodMC
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cost
EUROPEAN COOPERATION
IN SCIENCE AND TECHNOLOGY

Florent Vieux, PhD
florent.vieux@ms-nutrition.com

MS - Nutrition

- Start'up founded in February 2014

- Located in Marseille

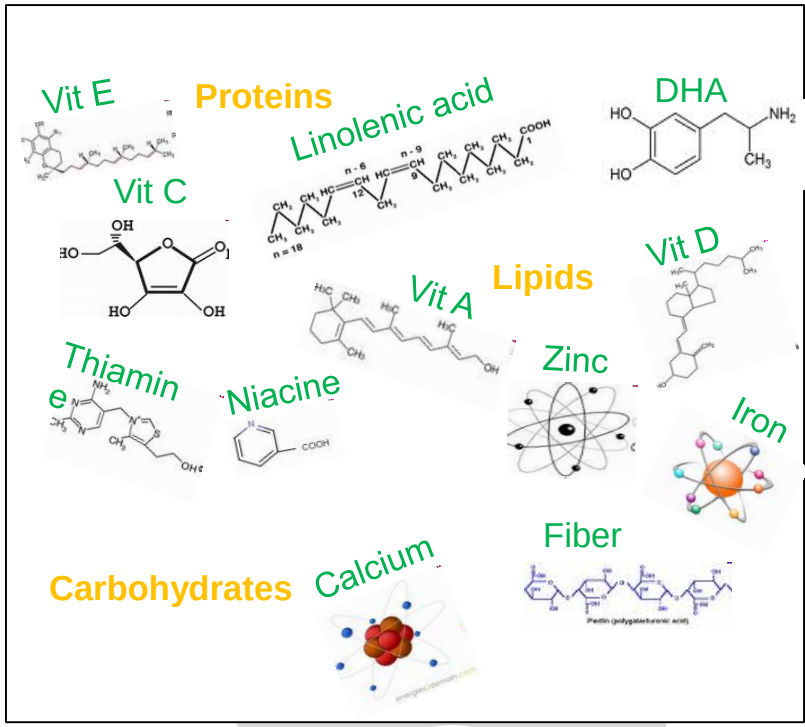
- Hosted in a research laboratory of nutrition, in the faculty of medicine *La Timone* (Marseille)

- Technology transfert: rent of informatic license

- Our partners: public research institutes and universities, private stakeholders

Background

We eat FOODS… BUT We need nutrients



=> Recommended dietary allowances

=> Maximum Recommended Values
for saturated fats, free sugars, sodium

Background

We eat FOODS… BUT We need nutrients

Nutrition Facts

Serving Size 1 muffin
Servings Per Container 2

Amount Per Serving	
Calories 250	Calories from Fat 110
	% Daily Value*
Total Fat 12g	18%
Saturated Fat 3g	15%
Cholesterol 30mg	10%
Sodium 470mg	20%
Total Carbohydrate 31g	10%
Dietary Fiber 3g	12%
Sugars 5g	
Protein 5g	

How to help people to improve the nutritional quality of their diets?

Levers of change: make healthier food choices

Food labelling

Nutrient profiling

science of classifying or ranking foods according to their nutritional composition for reasons related to preventing disease and promoting health

WHO website

Promotion of food

Food (re)formulation

Food based dietary guidelines

advice on foods, food groups and dietary patterns to provide the required nutrients to the general public to promote overall health and prevent chronic diseases.

FAO website

No bad foods, only bad diets

Relationship of nutrient profiling to food-based dietary guidelines

Food-based dietary guidelines are recommendations for **healthy eating, framed in terms of foods and food patterns**. **Nutrient profile** models **classify foods based on their nutrient composition**, and this information can be used to help in achieving dietary recommendations. Thus, **nutrient profile models need to complement and support food-based dietary guidelines in the regions or countries in which they are applied.**

World Health Organisation, 2010

« the total diet or overall pattern of food eaten is the most important focus of healthy eating. **All foods can fit within this pattern** if consumed in moderation with appropriate portion size and combined with physical activity ».

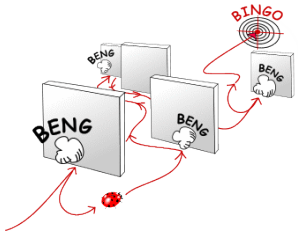
Academy of Nutrition and Dietetics, 2014

Why linear programming is a well adapted tool to derive and validate nutrient profiles and FBDG ?

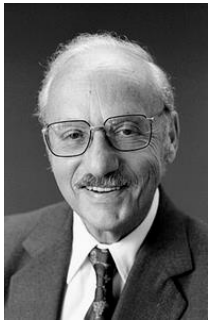
Linear programming was born to solve a problem related to nutrition

"How much of 77 foods should be eaten on a daily basis so that a man's intake of nine nutrients will be at least equal to the recommended dietary allowances (RDAs) with the cost of the diet being minimal?"

George Stigler, the cost of subsistence, 1945



Stigler diet problem
Use of trial and errors method
39.93$/year



1947:discovered the simplex method (the heart of linear programming) and applied it to define a low cost diet that would meet the nutritional needs of a GI soldier

Application of the simplex algorithm to the Stigler diet problem (Laderman, 1948)
39.69$/year

Principle of Linear Programming in diet modelling

1. Foods and Data =Variables

- List of 77 foods
- Nutritional composition (8 nutrients), energy, price

2. Targets = mathematical constraints

- On **nutrients**:

- nutrient-based recommendations RDA

3. Specific question = objective function

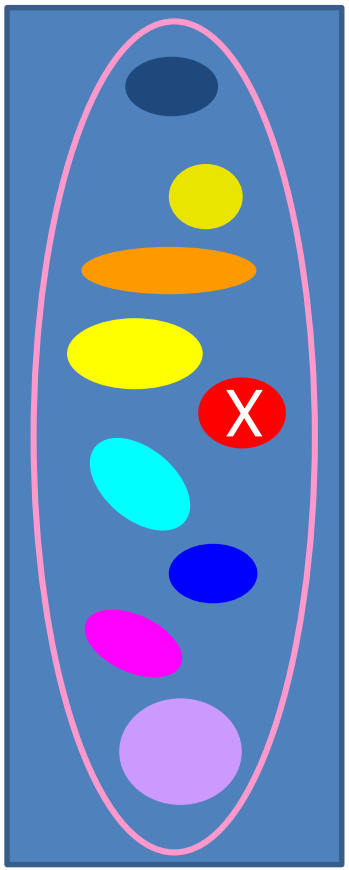
Minimum Diet cost?

4. OPTIMISATION

selection of foods and their weight to achieve all constraints:

Evolution of diet modelling in the 70's

Minimizing the departure from an existing diet (The thrifty food plan)



Observed diet

current average consumption of low-income Americans

Variables

Consumed foods and their quantities,
New foods if needed

Constraints

Iso Energy

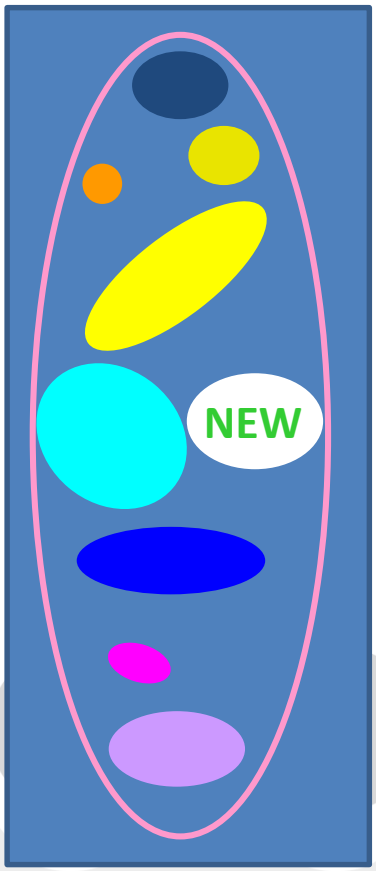
Nutrient recommendations

Maximal quantities of foods and food groups, and max total diet weight

Cost, and/or any other food-related characteristic

Objective function & optimization

Minimal departure from the observed diet



Optimized diet

nutritionnally adequate & socially acceptable

Evolution of diet modelling in early 2000

Incorporating additional information

1. Foods and Data =Variables

- List of foods
- Nutritional composition (more than 30 nutrients), price
- toxicological content, carbon impact…

2. Targets = mathematical constraints

- On **nutrients**:

- nutrient-based recommendations as EARs or RDAs

- On **foods** :

- food-based recommendations as MyPyramid
- dietary habits at individual or population level (maximal amount, portion size, balance between food-groups…)

- Others :

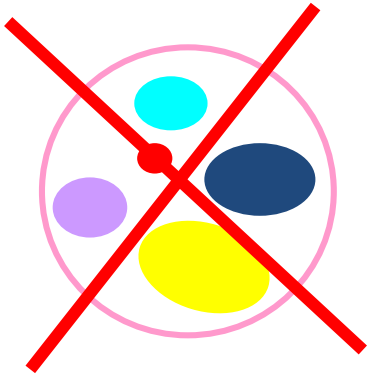
- diet cost, total weight, total energy …

3. Specific question = objective function

Minimum Diet cost? Minimum energy needed? Minimum deviation from an existing food basket?

4. OPTIMISATION

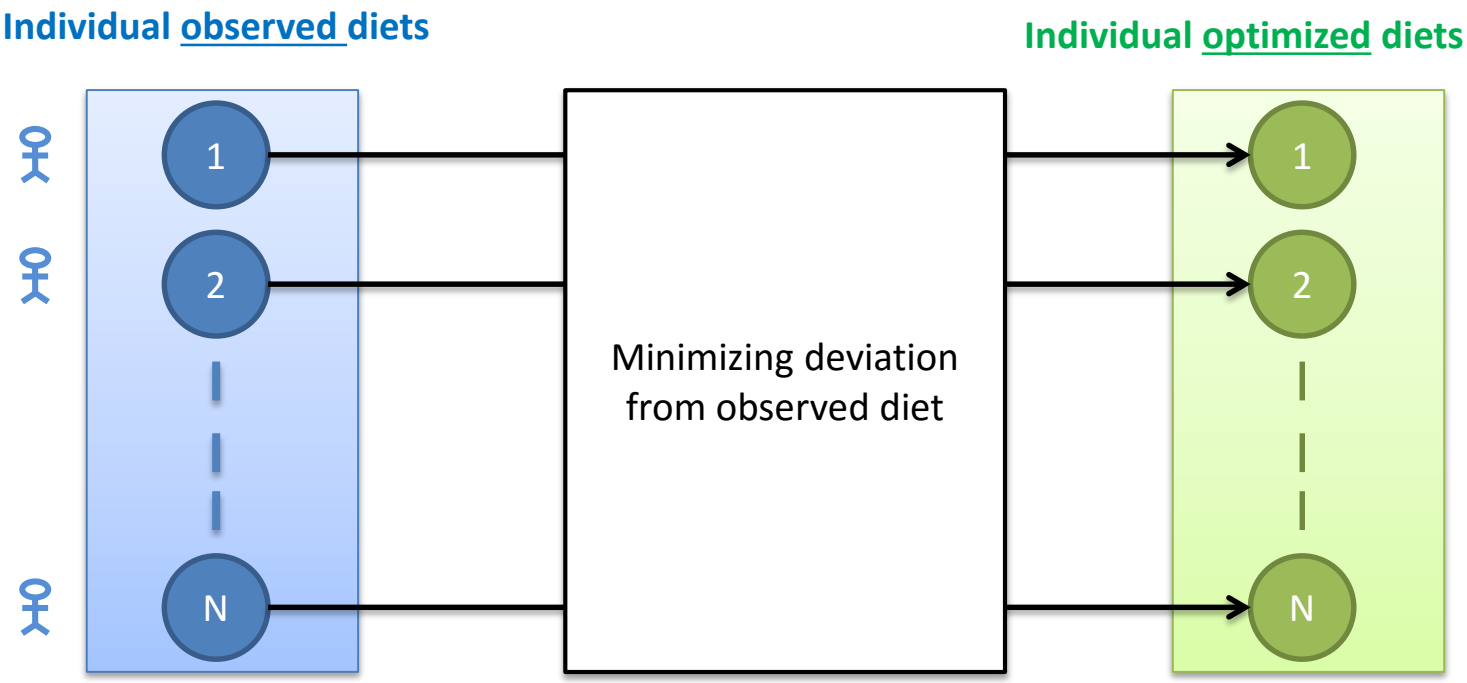
selection of foods and their weight to achieve all constraints:



Solution may be infeasible ….

Evolution of diet modelling in early 2010

Individualisation



Inadequate intakes

Adequate intakes

- Macro-nutrients
- Essential fatty acids
- Fiber
- Vitamins
- Cholesterol
- Minerals

Illustrations of how LP can be used to :

- **Develop dietary guidelines**

Individual diet modeling translates nutrient recommendations into realistic and individual-specific food choices[1–3]

Matthieu Maillot, Florent Vieux, Marie Josèphe Amiot, and Nicole Darmon

- **Test nutrient profiling systems**

Quantifying the contribution of foods with unfavourable nutrient profiles to nutritionally adequate diets

Matthieu Maillot[1,2], Adam Drewnowski[3], Florent Vieux[1,2], and Nicole Darmon[1,2*]

- **Identify the role of a given food in a healthy diet**

nutrients MDPI

Article

Role of Young Child Formulae and Supplements to Ensure Nutritional Adequacy in U.K. Young Children

Florent Vieux [1,*], Chloé M. C. Brouzes [2], Matthieu Maillot [1], André Briend [3,4], Régis Hankard [5], Anne Lluch [2] and Nicole Darmon [6]

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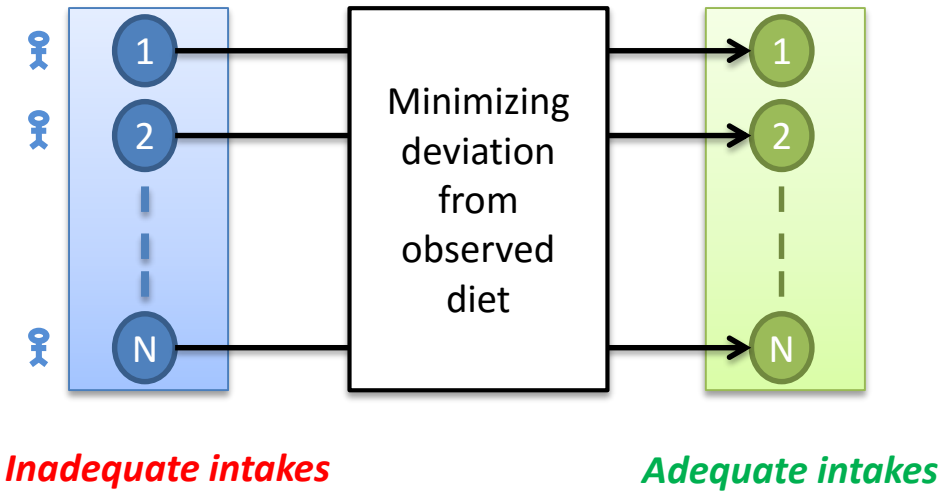
What kind of foods are needed to reach nutritional goals ?

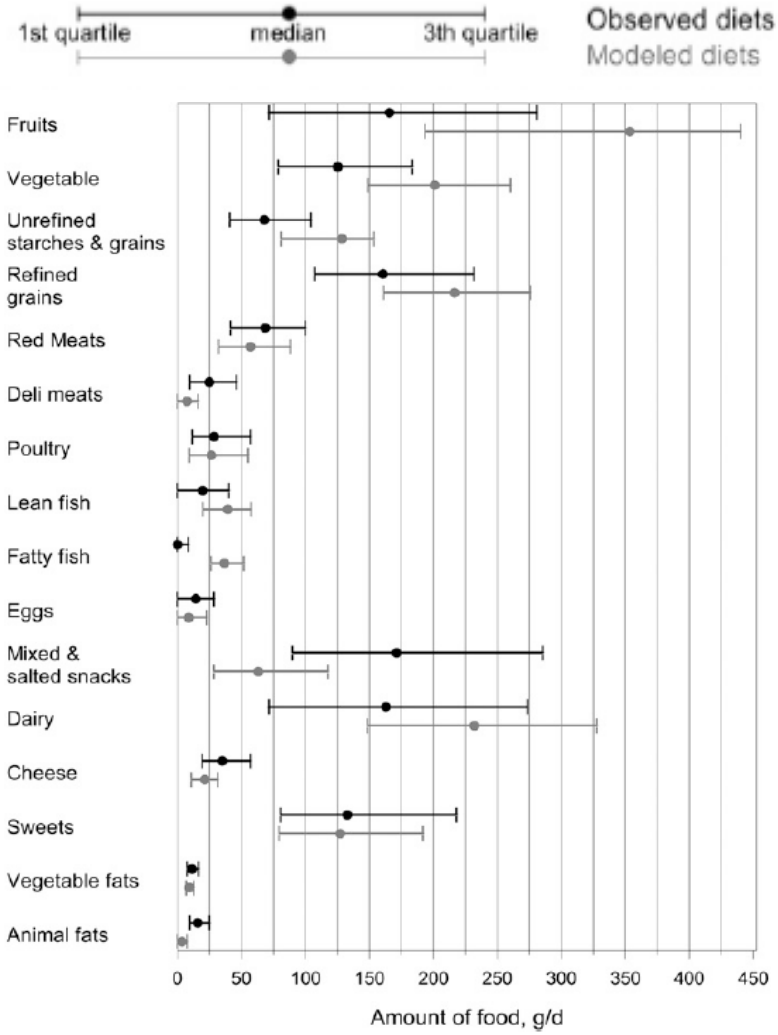
Method

Application of individual diet modelling to a national representative sample of French adults



Comparaison of the quantities of foods between observed and optimized diets

Results



There are as many different optimized diets as the number of observed diets (here n= 1171)

General tendencies: Increase in Plant-based foods, fish and fresh dairies and decrease deli meat, cheese & animal fats

In accordance with food based dietary guidelines

Added value: take individual preferences into account -> better adherence by the population

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How foods with different nutritional profiles fit in nutritionally adequate diets?

Individual Diet Modelling and Nutrient Profile

SAIN,LIM system

Darmon et al. AJCN 2009

$$SAIN_i = \frac{\sum_{p=1}^{p=5} ratio_{ip}}{5} \times 100$$

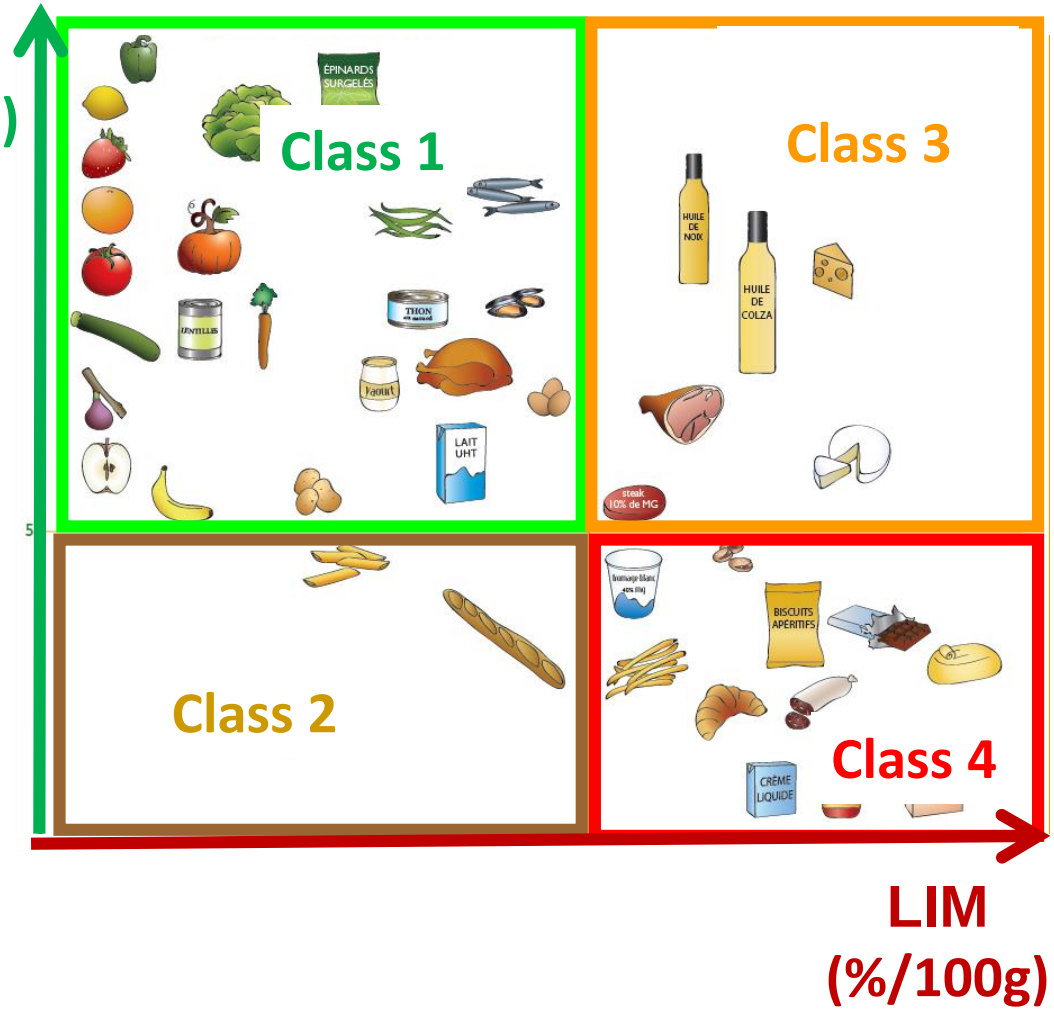
$$ratio_{ip} = \frac{nutrient_{ip}}{Recommended\ Valuep} \times \frac{100}{E_i}$$

-> Reflects the positive aspects of foods

$$LIM_i = \frac{\sum_{l=1}^{l=3} ratio_{il}}{3}$$

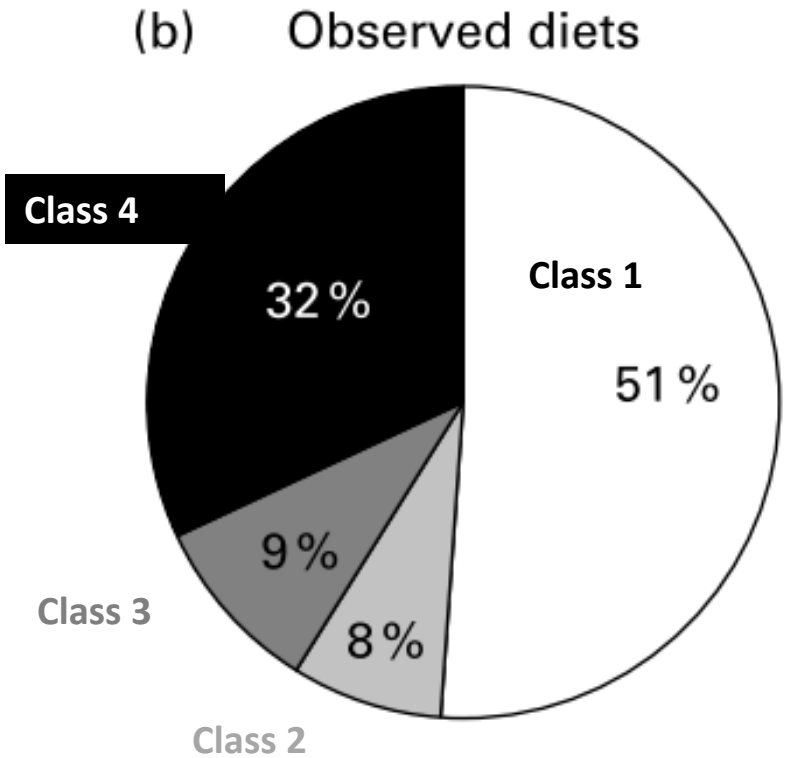
$$ratio_{il} = \frac{nutrient_{il}}{Maxi\ Recommended\ Valuel} \times 100$$

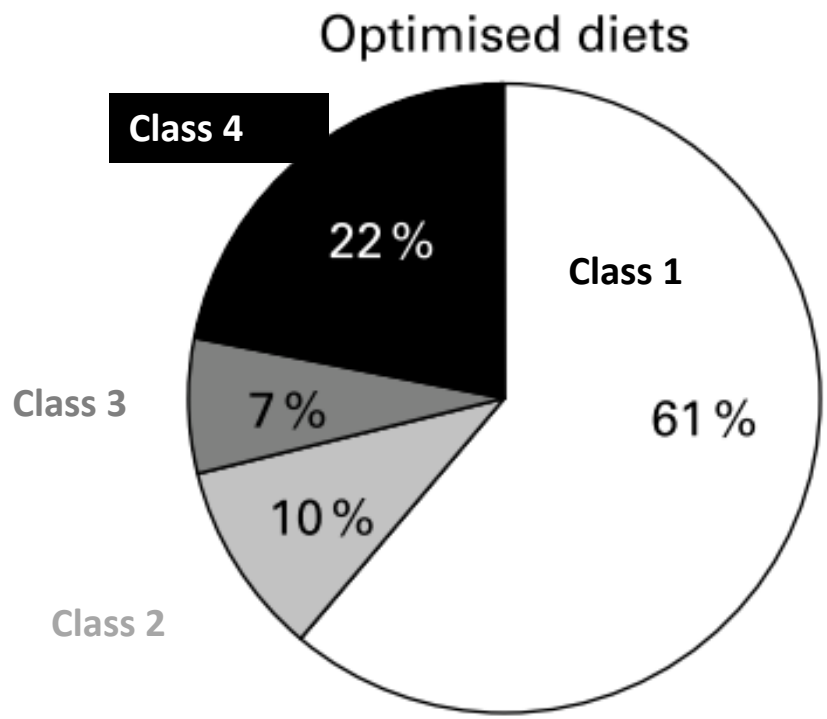
-> Reflects the negative aspects of foods



Individual Diet Modelling and Nutrient Profile

How foods fit in a nutritionally adequate diet?





Contribution to total weight, %

Contribution to total weight, %

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Maillot et al. Br J Nutr 2011 Apr;105(8):1133-7

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What role for young child formulae (YCF) in nutritionally adequate diets?

Background

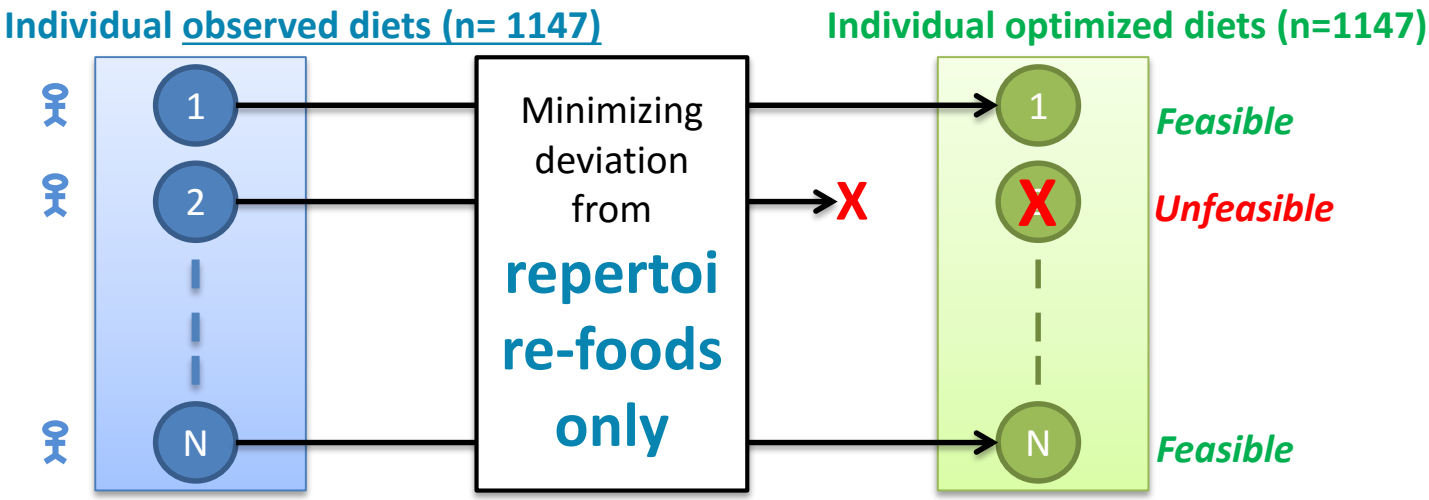
In the UK, more than 60% of 12-18 months old young children do not consume neither young child formulae, nor supplement

Consumption of…		…young child formulae (YCF)?	
		Yes	No
…Supplement?	Yes	*YCF & Suppl (3%)*	*no YCF Suppl (5%)*
	No	*YCF no Suppl (30%)*	*no YCF no Suppl (62%)*

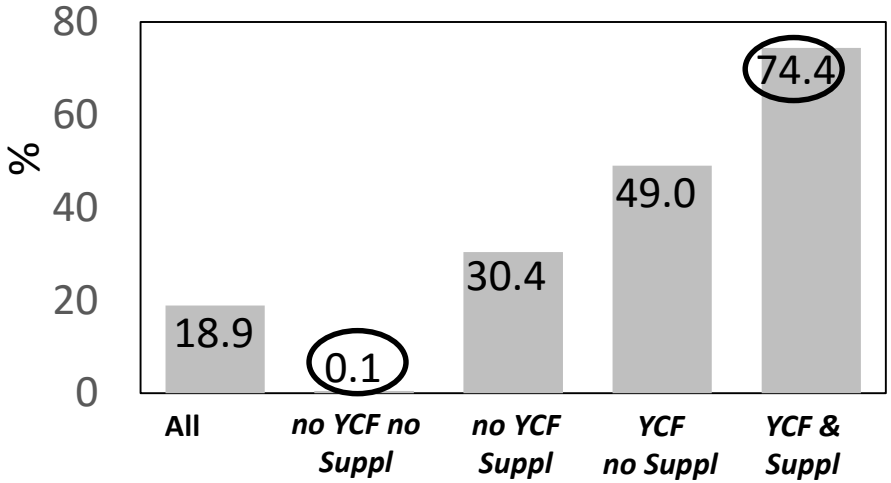
In this context,

- Is the consumption of YCFs and/or supplements strictly necessary to ensure nutritional adequacy?
- What are the dietary changes needed to meet nutritional adequacy?

Use of individual diet modelling to estimate the role of YCF for meeting nutrient adequacy



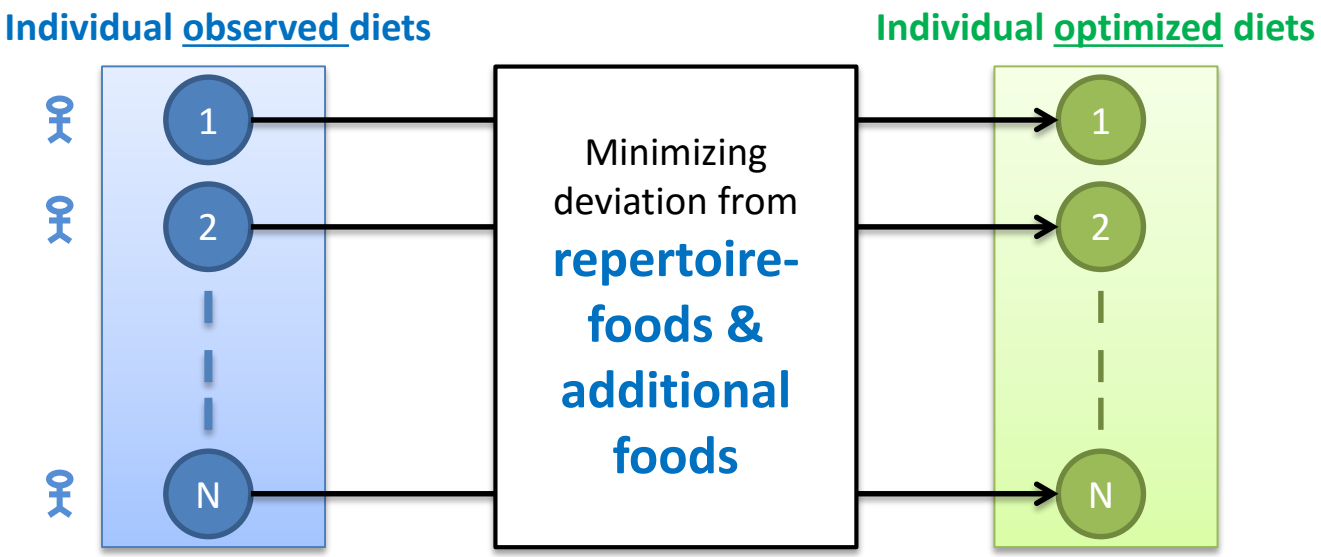
Percentage of children for whom it is possible to model a nutritionally adequate diet from their food-repertoire only in the 4 groups of children (N=1147)



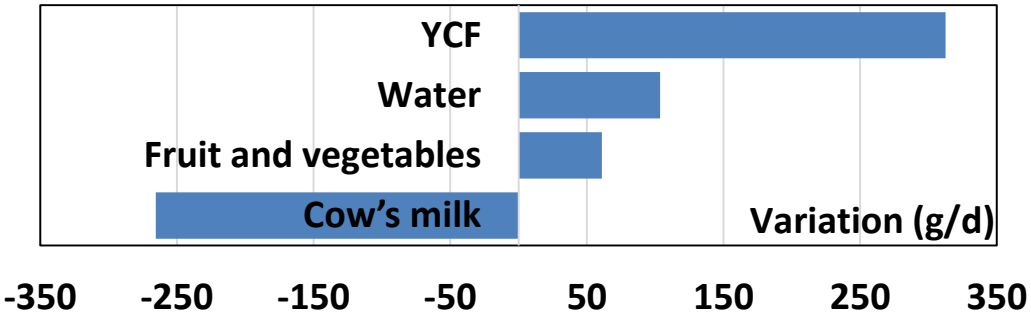
Only **1 children out** of the 707 ***'no YCF no Suppl'* could meet nutrient requirements** with his/her repertoire-foods only (without introducing YCF or Suppl)

YCF and/or supplement consumption **increased the feasibility of modelling a nutritionally adequate diet**

Use of individual diet modelling to estimate the role of YCF for meeting nutrient adequacy



Main mean variations between modelled and observed diets in the '*no YCF no Suppl*' group of children (N=707)

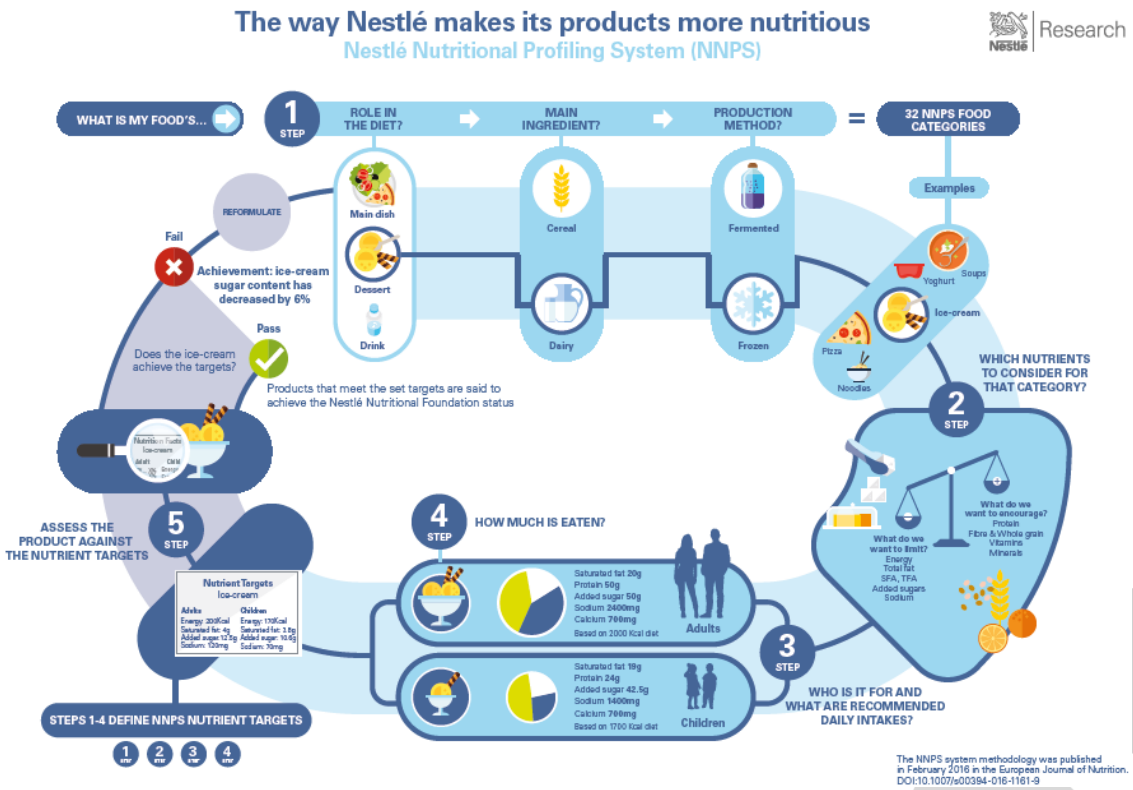


With access to all foods, **all nutrient recommendations could be met for all children** (ie, 100% feasibility)

In the No/No group, in average, **313g/d of YCF and 0.82g/d of supplements** were needed to meet nutrient requirements; as well as a **decrease of 265g of cow's milk** and an **increase of 61g of fruit&veg.**

How to apply LP at the food level in order to improve nutritional quality of the offer?

Example: The Nestlé Nutritional Profiling System for reformulation of food products



It looks like a trial and errors methodology… Does it remind something to you?

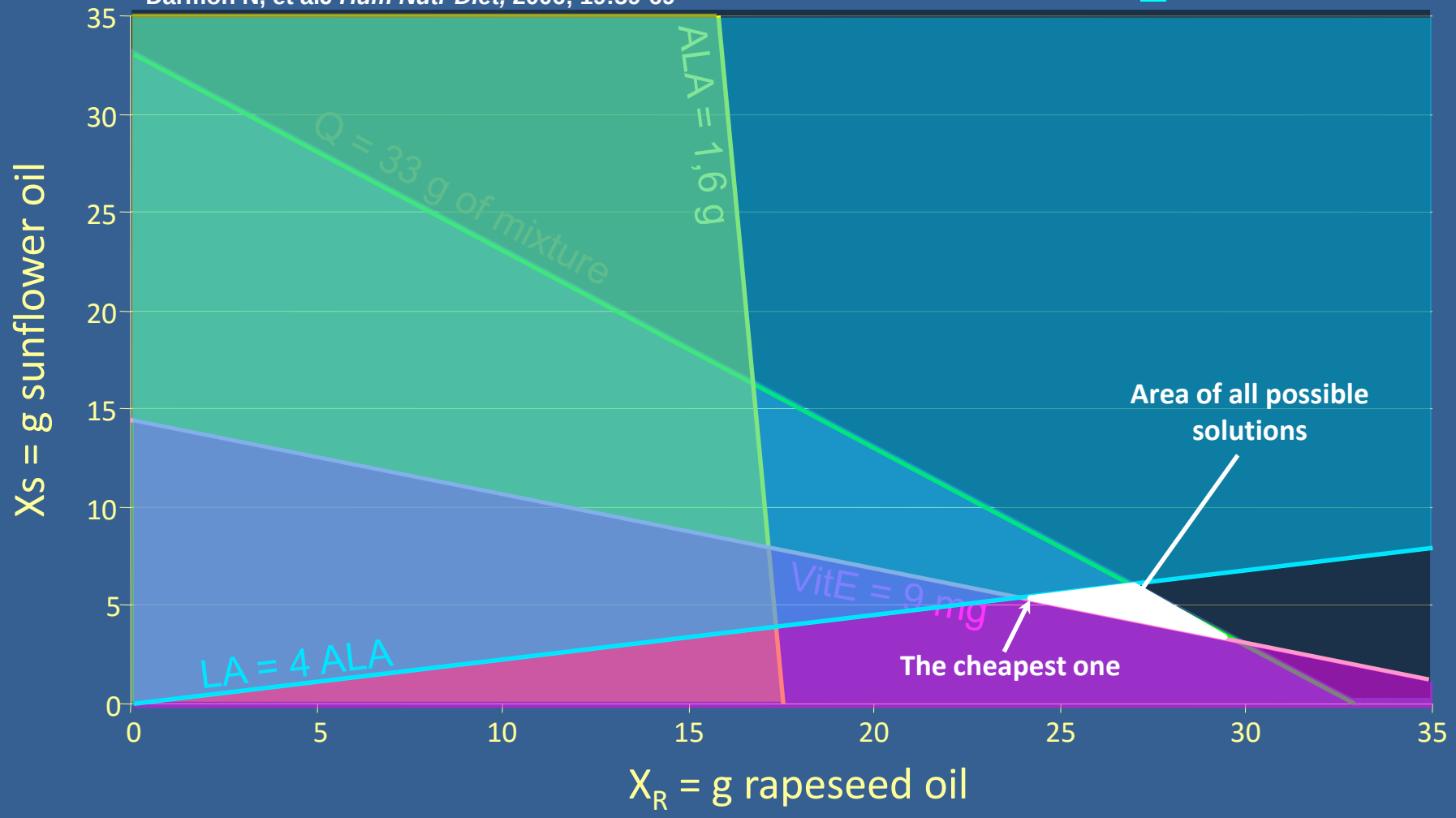
The Stigler approach!

Would it be possible to use LP?

Graphical illustration of an oil mixture

Q ≤ 33 g of mixture
ALA ≥ 1.6 g
Vit E ≥ 9 mg
LA ≤ 4 ALA

Darmon N, et al*J Hum Nutr Diet,* 2006; 19:59-69



Reformulation of foods (for humans) is not so simple

Cost

Quality and consumer acceptance

Taste

Food safety

Processing

Nutritional composition of ingredients

We are at the very beginning of the work on this subject

Any help is welcome!

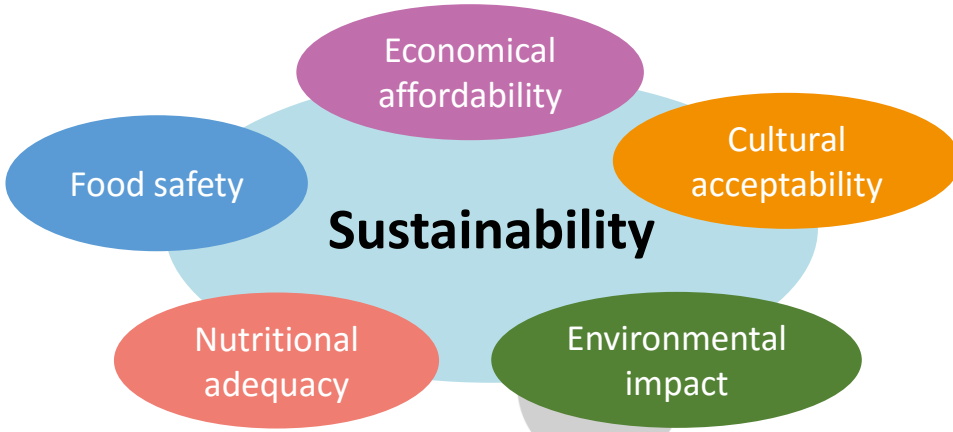
Discussion

Linear programming was found to be a powerful tool
to solve the historical « diet problem »
to help in public health nutrition

It evolved with the rise of information on food consumption (**dietary surveys**) and on **nutrient content**

It is able to take many dimensions into account:

Toxicological contents
Carbon footprint
Price...



We would be happy to discuss the way of applying LP (or an other approach) in the field of food reformulation

Thank you for your listening

Nicole Darmon, PhD

Matthieu Maillot, PhD

Marseille