From sustainable diets to sustainable food systems: putting nutrition at the heart

Nicole Darmon
INRA, Human Nutrition Department, France
(nicole.darmon@inra.fr)
What is said about nutrition and the environment?

(i) High contribution of food sector to greenhouse gas emissions GHGE (15-31%)

(ii) High GHGE of animal vs plant-based products:

(iii) Plant-based diets recommended for health

→ Convergence between health and environmental objectives generally admitted
Definition of Sustainable diets

(FAO, 2010)

Sustainable diets: respect of the 4 dimensions

Health & nutrition
“nutritionally adequate, safe and healthy”

Environment
“protective and respectful of biodiversity and ecosystems”

Culture
“culturally acceptable”

Economy
“accessible, economically fair and affordable”

Sustainable Diets
Sustainable diets metrics

Need for reliable indicators for each dimension

- Nutrient content of food
- Nutrient-based recommendations
- Energy Density, Nutrient density
- Nutritional quality scores

• Greenhouse gas emissions (GHGE)
  • Acidification, Eutrophication

Health & Nutrition

Culture

- Observed dietary intakes
- Commonly consumed food

Sustainable Diets

Environment

Economy

- Budget for food
  - Average food prices
Need for reliable and connected data

Aggregation of data from heterogeneous sources:
- Choice of a common categorisation system
- Development of linkage methodologies

*energy, nutrients, anti-nutrients, data for bioavailability assessment
** distribution of food and nutrient intakes, usual portions, food patterns

(Gazan et al, Food Chemistry, 2017)
Mean daily GHGE
4090 g eq.CO₂

— Mean daily GHGE
4090 g eq.CO₂

Distribution

Women
3658 g eqCO₂/d

Men
4725 g eqCO₂/d

High inter-individual variability

Diet-related GHGE higher for men than for women

(Vieux et al, Ecol, Econ 2012)
GHGE of self-selected diets in France

\( R^2 = 0.29 \)

(A. Quantities (g/d)

\( R^2 = 0.62 \)

(B. Energy intakes (kcal/d)

Strong positive correlation between quantities and GHGE

Waste less and eat less for a lower environmental impact
Correlation between nutritional quality indicators and diet-related GHGE

(Vieux et al, AJCN 2013)

<table>
<thead>
<tr>
<th>MAR</th>
<th>MER</th>
<th>ED</th>
</tr>
</thead>
<tbody>
<tr>
<td>Mean Adequacy Ratio</td>
<td>Mean Excess Ratio</td>
<td>Energy Density</td>
</tr>
<tr>
<td>Diet GHGE</td>
<td>0.27</td>
<td>-0.14</td>
</tr>
</tbody>
</table>

unexpectedly, in self-selected French diets, higher nutritional quality was associated with higher GHGE

why? Answer at the food level?
What is said about nutrition and the environment

(i) High contribution of food sector to GHGE (15-31%)

(ii) High GHGE of animal vs plant-based products:

(iii) Plant-based diets recommended for health

CO₂ data: Bertoluci, 2016
Something wrong with current reasoning?

(ii) High GHGE of animal vs plant-based products?

Not all animal products have high carbon impact
(iii) Plant-based diets recommended for health?

The most consumed (and the cheapest) plant-based products have low environmental impact but aren’t the most recommended for health.
Something wrong with current reasoning?

(iii) Plant-based diets recommended for health?

The least healthy plant-based products are among the least impacting ones (and the cheapest calorie sources)

GHGE (kg CO₂ eq./kg) 0 2.5 5 15

CO₂ data: Bertoluci, 2016

→
Need to act both on food choice and quantities

- Nutritional epidemiology to identify positive deviants
- Diet modelling to design sustainable diets
Identification of ‘positive deviants’  

(Masset et al, AJCN 2014)

General Population

Dietary survey (INCA2)

Catégorisation of individual diets

PANDiet > median + GHGE < median

Positive deviants have dietary-GHGE 20% lower vs mean:
- Half because they eat less (200 and 300 kcal less for M&W respect.)
- Half because they eat differently
More sustainable self-selected diets (GHGE reduced by 20%): small decrease of animal products and small increase of plant-based products

% weight from plants: 53% => 58%
Diet cost: 6.7€/d => 6.2€/d

(Masset et al, AJCN 2014)
Is it possible to reduce GHGE by more than 20% while reaching nutritional adequacy?

**Answer with:**

- Diet modeling with linear programming (LP)
VARIABLES (Food and their weights)

CONSTRAINTS
(Requirements for the modeled diet)
- Iso Energy
- Realism and acceptability (maximum portion sizes, balance between food-groups, ...), based on observed intakes
- GHGE progressively reduced (10% steps)
- Cost < Observed cost
- All nutritional recommendations

OBJECTIVE FUNCTION
Minimizing departure from the observed diet
30-40% GHGE reduction: possible to design a nutritious diet without increasing cost, with moderate deviation from current intakes

=> More F&V, Less Meat (proteins decreased from 150% to 125% RDA)
The ADEQ Model

60% reduction: greater departure from observed food intakes: => Perhaps not sustainable?
Sustainable Diets

(FAO, 2010)

Diet is the right “functional unit” to consider
- Extreme dietary scenarios aren’t sustainable
- 30-40% GHGE reduction possible via food choices changes
- For greater reductions, actions on the food supply are required

Health & nutrition
- “nutritionally adequate, safe and healthy”

Environment
- “protective and respectful of biodiversity and ecosystems”

Culture
- “culturally acceptable”

Economy
- “accessible, economically fair and affordable”
Priority research for the next 10 years? INTEGRATION

Which tools for research & development are lacking? DATABASES

- Nutrient bioavailability
- Contaminants (heavy metals, pesticides, mycotoxins, PCBs, dioxin-like compounds)
- Toxicological references values

- Supplements
- New foods...

- Acidification, Eutrophication
- Land use, Water use
- Biodiversity
- Organic vs conventional
- Local vs global...

- Individual food preferences
- Social and religious restrictions
- Norms and beliefs...

- Socio-economic position of consumers
- Income & working conditions of producers
- Actual food prices, ‘Fair’ price
- Co-production links
Which types of partnerships are necessary for the development of bioeconomy?

Best way to understand something: modifying/improving it

Which new stakeholders?

In addition to producers, industry, retailers, consumers...
Health and diet professionals, urban planners and architects
Merci pour votre attention
THANK YOU
Many thanks to:

Florent Vieux
MS-Nutrition, Marseille, France

Matthieu Maillot
MS-Nutrition, Marseille

Gabriel Masset
Nestlé Research Center
Lausanne, Switzerland

Marlène Pérignon
Aix Marseille University, Marseille, France
LIMITS and PERSPECTIVES

➡️ Food safety?
➡️ Nutrient bioavailability?
  - Supplements
  - New food…

Nutrition

Sustainable Diets

Environment

Economy

- Acidification, Eutrophication
- Land use, Water use
- Biodiversity
- Organic vs conventional
- Local vs global…

Culture

- Individual food preferences
- Social and religious restrictions
- Norms and beliefs…

- Budget for food
- Socio-economic position of consumers
- Co-production links
- Income & working conditions for producers…
Reaching Nutritional Adequacy Does Not Necessarily Increase Exposure to Food Contaminants: Evidence from a Whole-Diet Modeling Approach

Tanguï Barré, Florent Vieux, Marlène Perignon, Jean-Pierre Cravedi, Marie-Josèphe Amiot, Valérie Micard, and Nicole Darmon

Conclusions: Based on a broad range of nutrients and contaminants, this first assessment of compatibility between nutritional adequacy and toxicological exposure showed that reaching nutritional adequacy might increase exposure to food contaminants, but within tolerable levels. However, there are some food combinations that can meet nutritional recommendations without exceeding observed exposures. J Nutr doi: 10.3945/jn.116.234294.
Adressing the limits ➔ Bioavailability

How taking it into account?

- **IRON absorption** ➔ **algorithm**\(^2\) taking into account **inhibitors / enhancers** content in diet

\[
\ln (\text{non-heme iron absorption}) = 6.294 + 0.119*\ln (\text{vitamin C}) + 0.006*\ln (\text{Meat/Fish/Poultry} + 0.1) - 0.055*\ln (\text{tea} + 0.1) - 0.247*\ln (\text{phytate}) - 0.137*\ln (\text{Calcium}) - 0.083*\ln (\text{non-heme iron}) - 0.709*\ln (\text{serum ferritin})
\]

- **ZINC absorption** ➔ **algorithm**\(^3\) taking into account **inhibitors / enhancers** content in diet

\[
T AZ = 0.5 \cdot \left( A_{\text{MAX}} + T D Z + K_R \cdot \left( 1 + \frac{T D P}{K_P} \right) \right) \\
- \sqrt{\left( A_{\text{MAX}} + T D Z + K_R \cdot \left( 1 + \frac{T D P}{K_P} \right) \right)^2 - 4 \cdot A_{\text{MAX}} \cdot T D Z}.
\]

\(T D Z: \text{Total Dietary Zinc, }\ T D P: \text{Total Dietary Phytate, }\ A_{\text{MAX}}=0.13, \ K_R=0.10\)

- **PROTEIN quality** ➔ **score**\(^1\) taking into account **amino acid content and protein digestibility**

Protein Digestibility Corrected Amino Acid Score (PDCAAS) = 

\% digestibility \times \text{amino acid score}

References:


Adressing the limits → Bioavailability

FIRST RESULTS:

(Perignon, submitted paper)

**ZINC absorption**
(French diets, n=1899)

**IRON absorption**
(French diets, n=1899)

- Variation of bioavailability poorly explained by the animal-to-plant ratio
- Large variability of bioavailability for a similar level of animal-to-plant protein ratio
- High bioavailability observed for A/P <1