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► **To cite this version:**

Nicole Darmon. From sustainable diets to sustainable food systems: putting nutrition at the heart. European Workshop on Bioeconomy, Institut National de Recherche en Sciences et Technologies pour l'Environnement et l'Agriculture (IRSTEA). FRA.; Institut National de la Recherche Agronomique (INRA). FRA., Jun 2017, Paris, France. 29 p. hal-02733487

HAL Id: hal-02733487

<https://hal.inrae.fr/hal-02733487>

Submitted on 2 Jun 2020

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EUROPEAN WORKSHOP ON BIOECONOMY

JUNE 28/29TH 2017, PARIS



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

Nicole Darmon

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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:

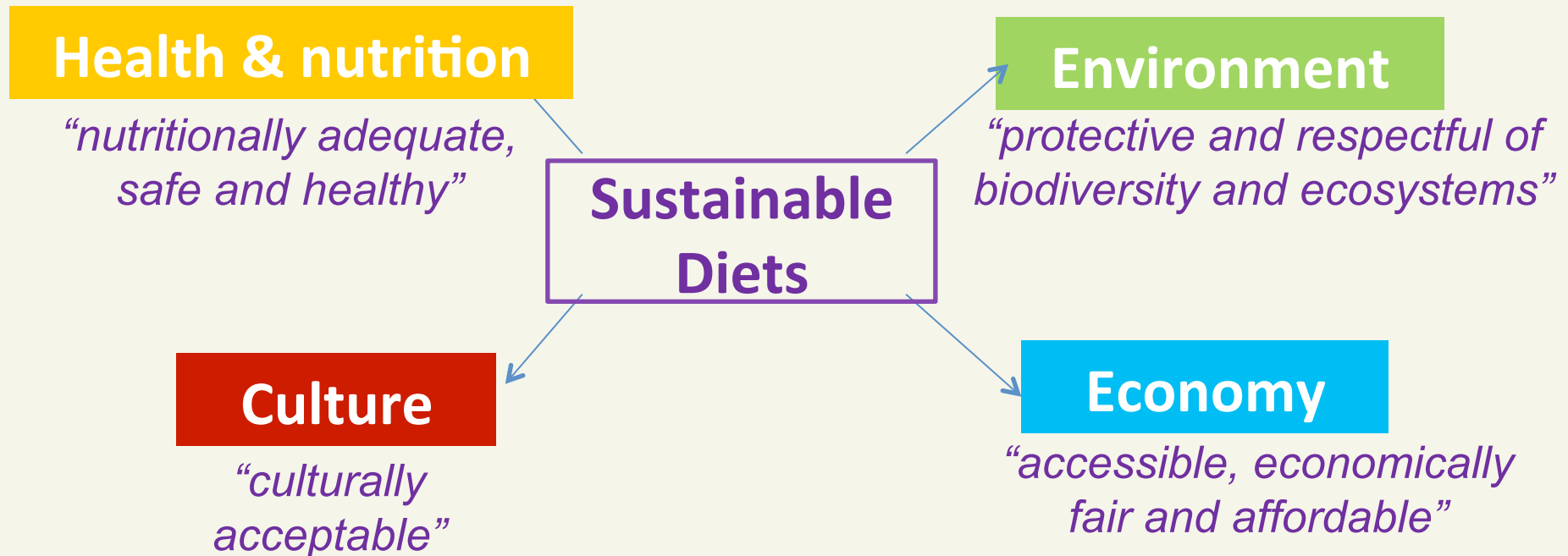


(iii) **Plant-based diets recommended for health**

➔ **Convergence between health and environmental objectives generally admitted**

Definition of Sustainable diets

(FAO, 2010)



➔ Sustainable diets: respect of the 4 dimensions

Sustainable diets metrics

➔ Need for reliable indicators for each dimension

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

Health & Nutrition

- Greenhouse gas emissions (GHGE)
- Acidification, Eutrophication

Environment

**Sustainable
Diets**

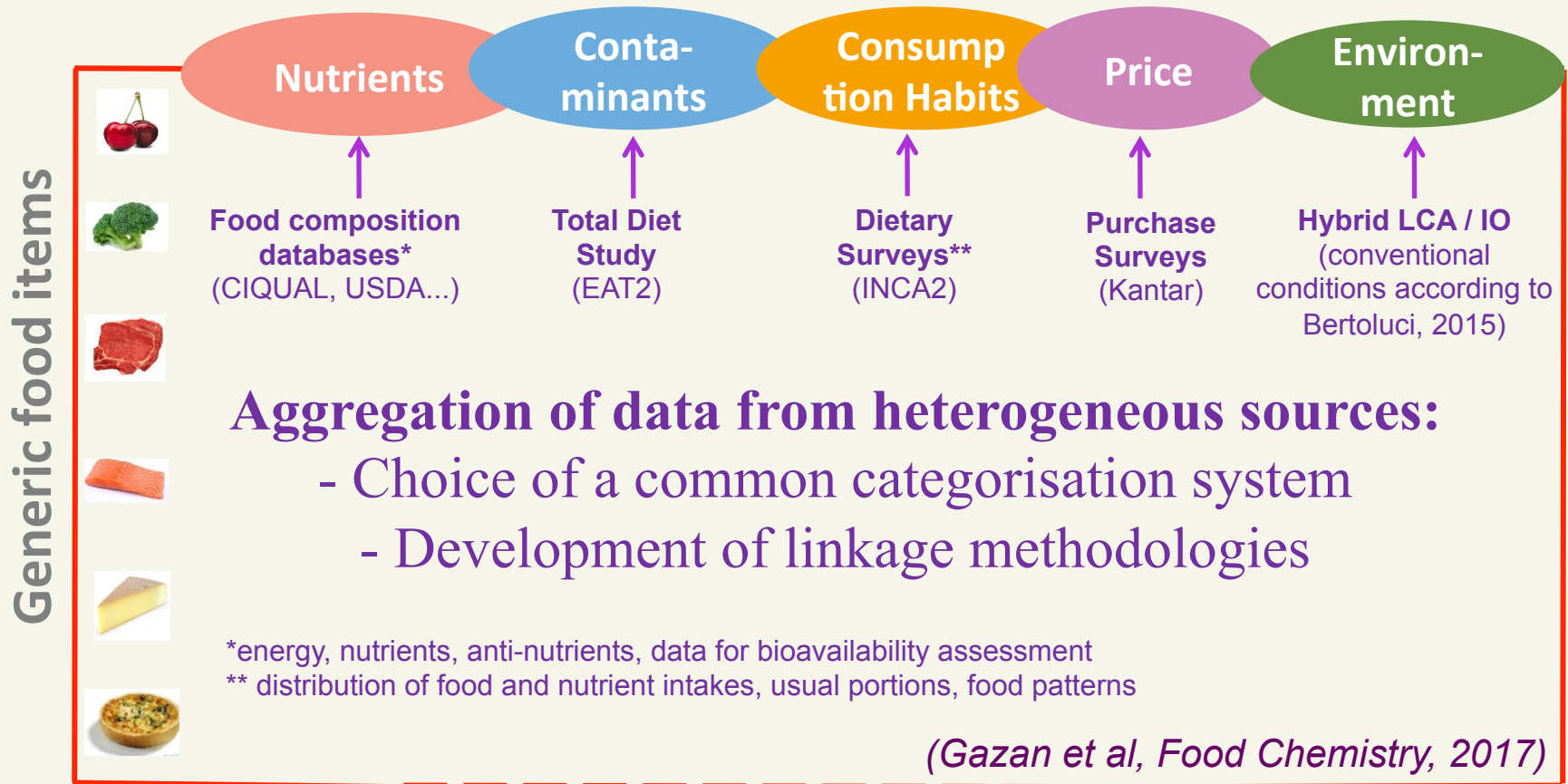
Culture

- Observed dietary intakes
- Commonly consumed food

Economy

- Budget for food
- Average food prices

➔ Need for reliable and connected data

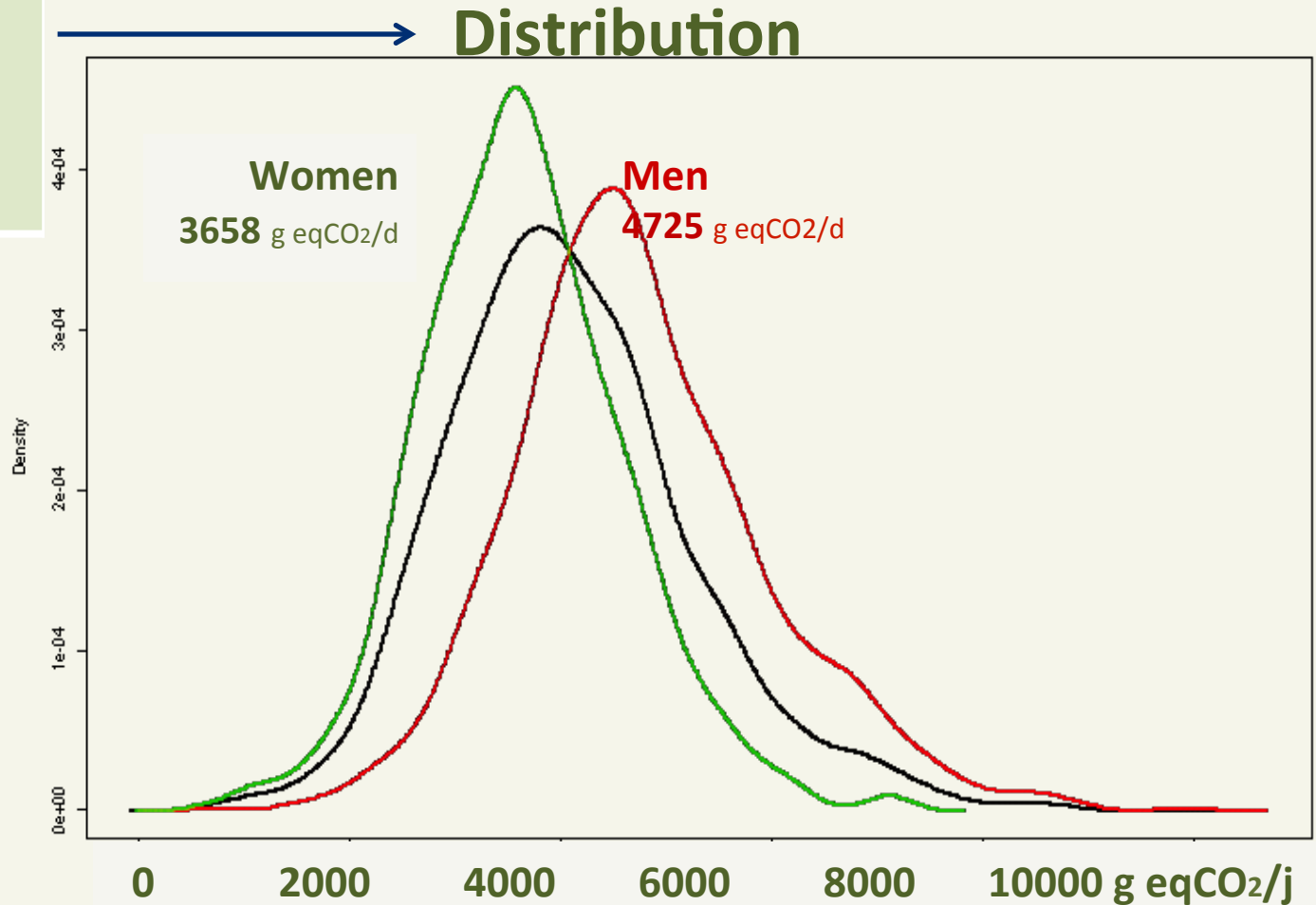


➔ Compilation of multiple metrics into a single database of generic foods for the study of sustainable diets in France

GHGE of self-selected diets in France

(Vieux et al, Ecol, Econ 2012)

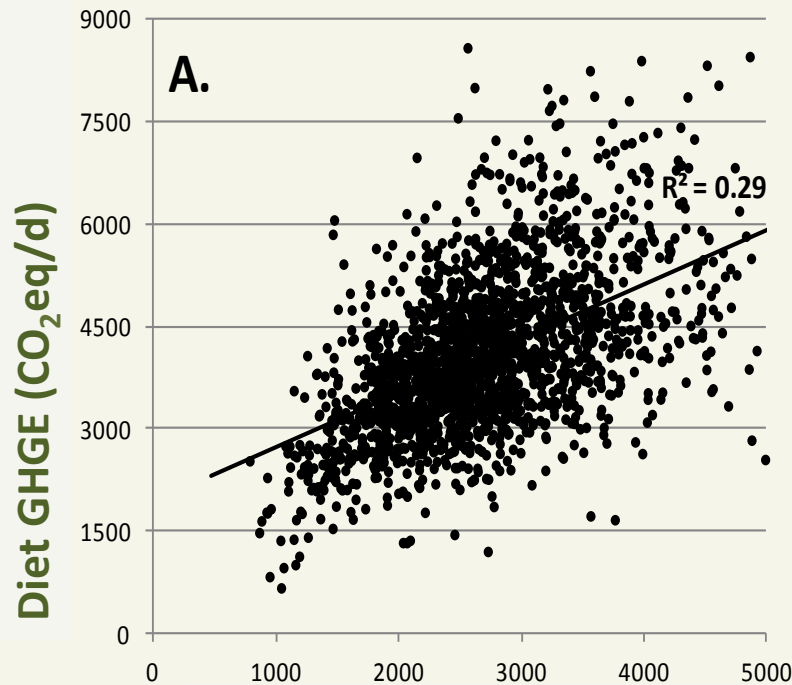
Mean
daily GHGE
4090 g eq.CO₂



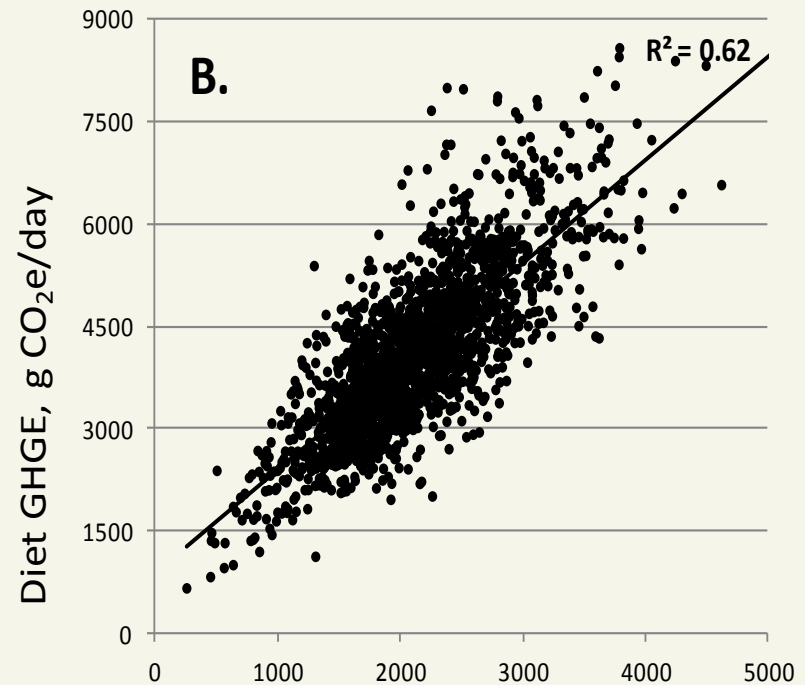
- High inter-individual variability
- Diet-related GHGE higher for men than for women

GHGE of self-selected diets in France

(Vieux et al, Ecol, Econ 2012)



A. Quantities (g/d)



B. Energy intakes (kcal/d)

→ Strong positive correlation between quantities and GHGE

→ Waste less and eat less for a lower environmental impact

(Vieux et al, AJCN 2013)

Correlation between nutritional quality indicators and diet-related GHGE

| | MAR | MER | ED |
|-----------|---------------------|-------------------|----------------|
| | Mean Adequacy Ratio | Mean Excess Ratio | Energy Density |
| Diet GHGE | 0.27 | -0.14 | -0.33 |

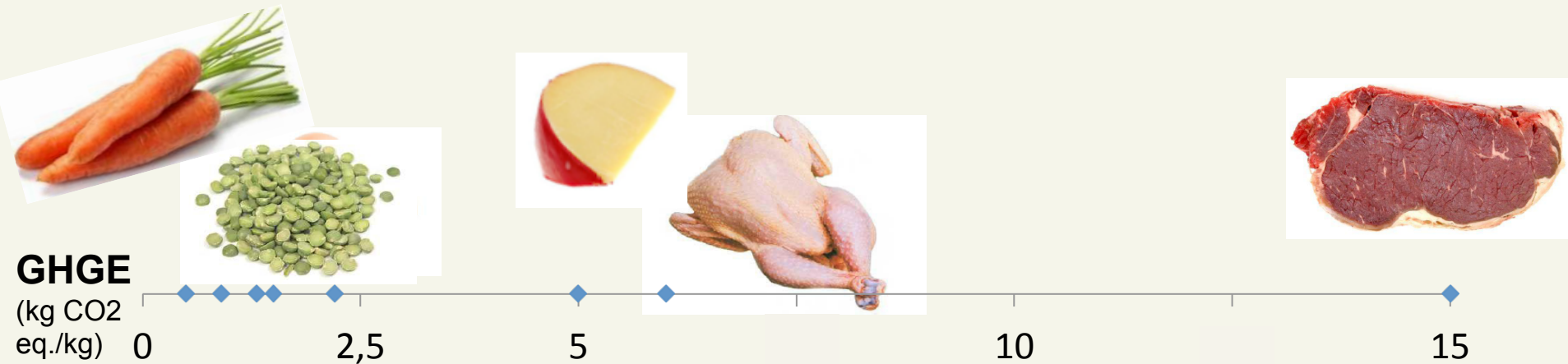
(age, sex and energy-adjusted)

- 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:

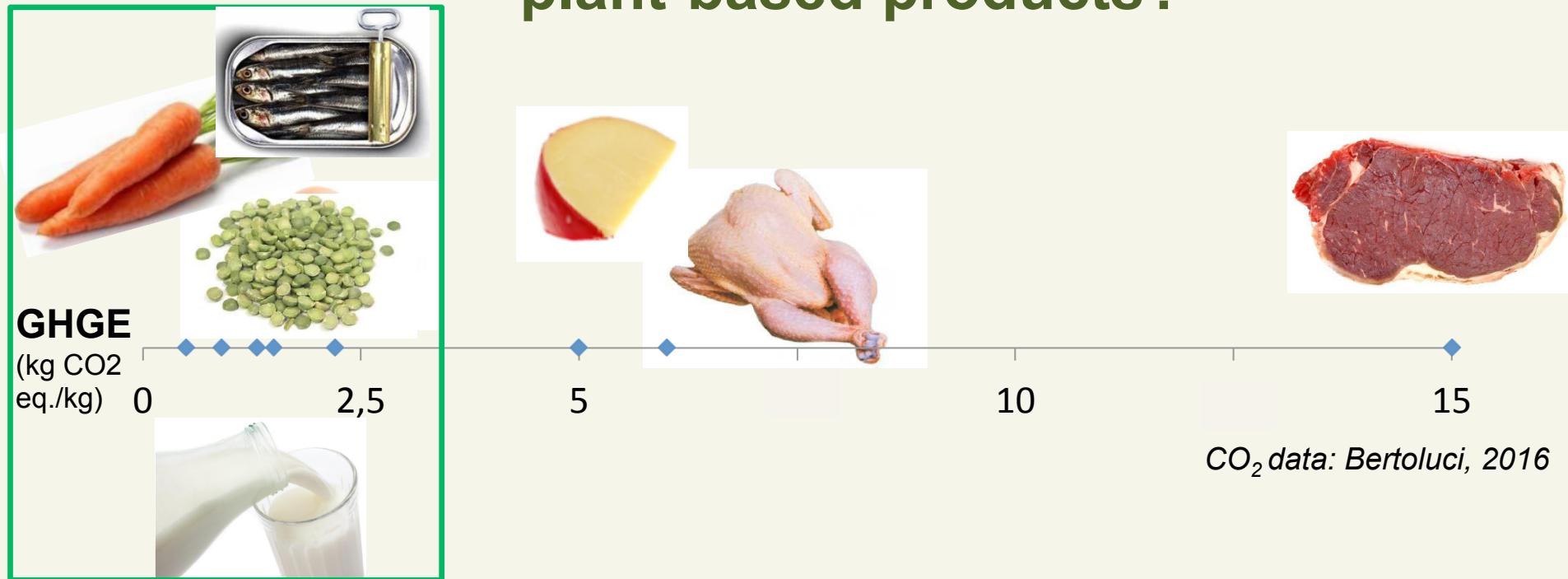


CO₂ data: Bertoluci, 2016

(iii) Plant-based diets recommended for health

Something wrong with current reasoning?

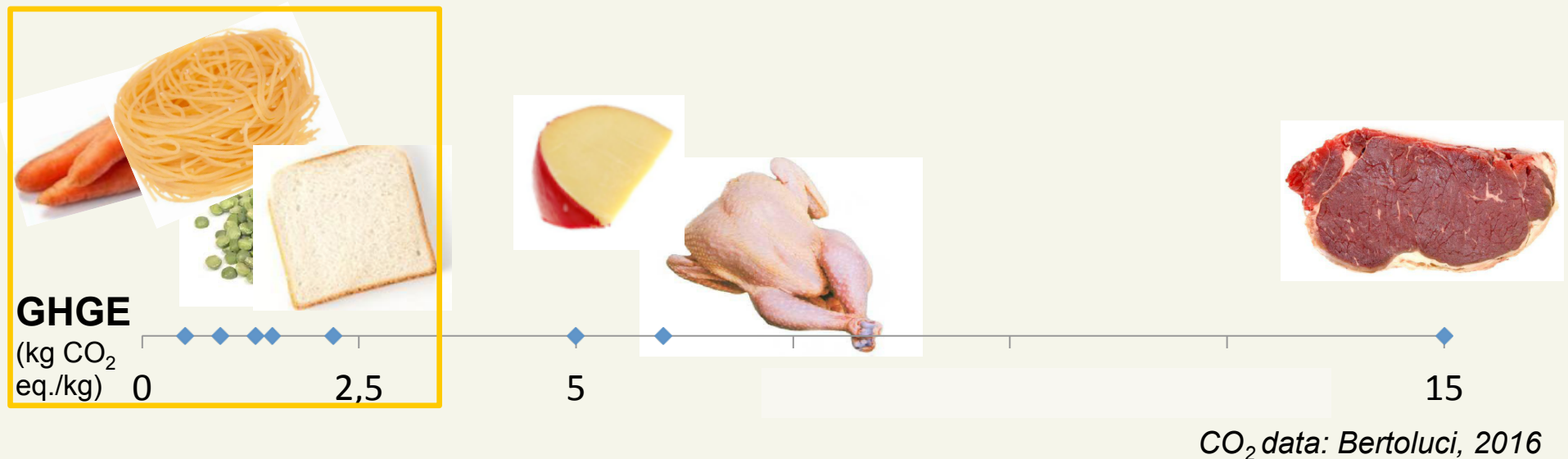
(ii) High GHGE of animal vs plant-based products?



➔ Not all animal products have high carbon impact

Something wrong with current reasoning?

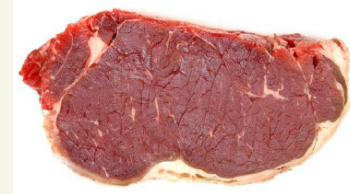
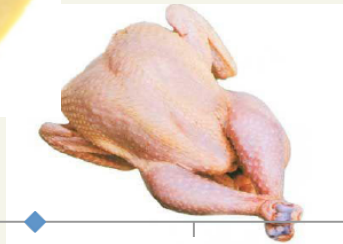
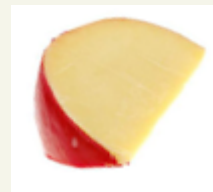
(iii) Plant-based diets recommended for health?



→ 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?



5

15

CO₂ data: Bertoluci, 2016

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

Nutrition

Culture

Economy

Environment

Reconciling the 4 dimensions within a diet?

Quantity for 2300 kcal

0,75 kg

1,45 kg

1,85 kg



THE FRENCH SUSTAINABLE DIET?



Energy density 300 kcal/100g

160 kcal/100g

125 kcal/100g

(WRCF/IARC recommendation)

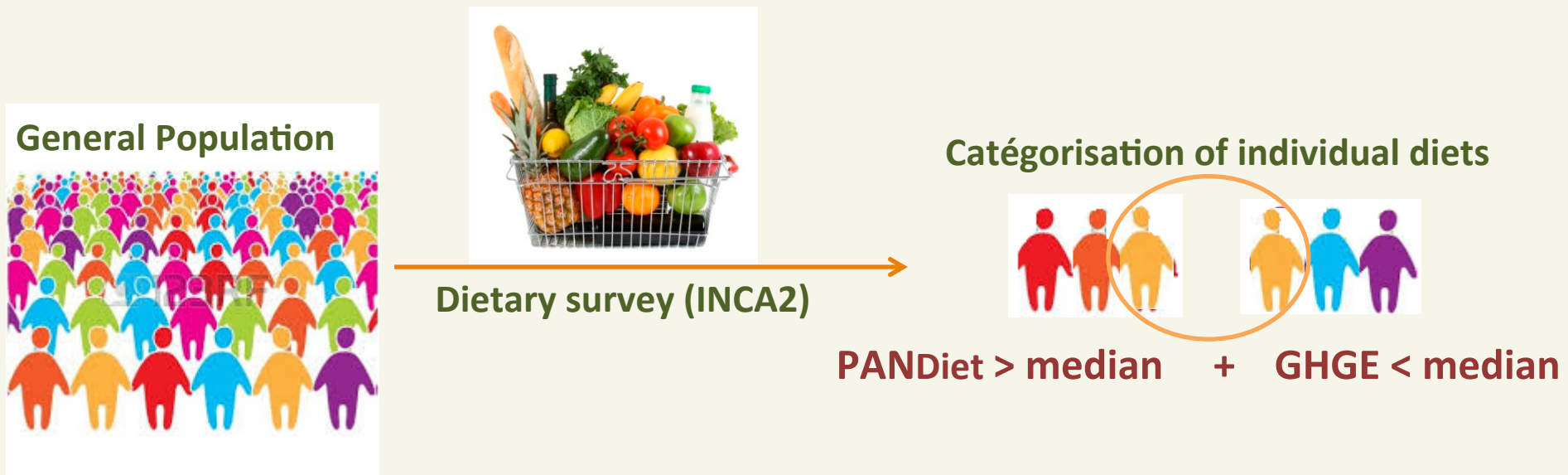
➔ Need to act both on food choice and quantities

➔ Nutritional epidemiology to identify positive deviants

➔ Diet modelling to design sustainable diets

Identification of 'positive deviants'

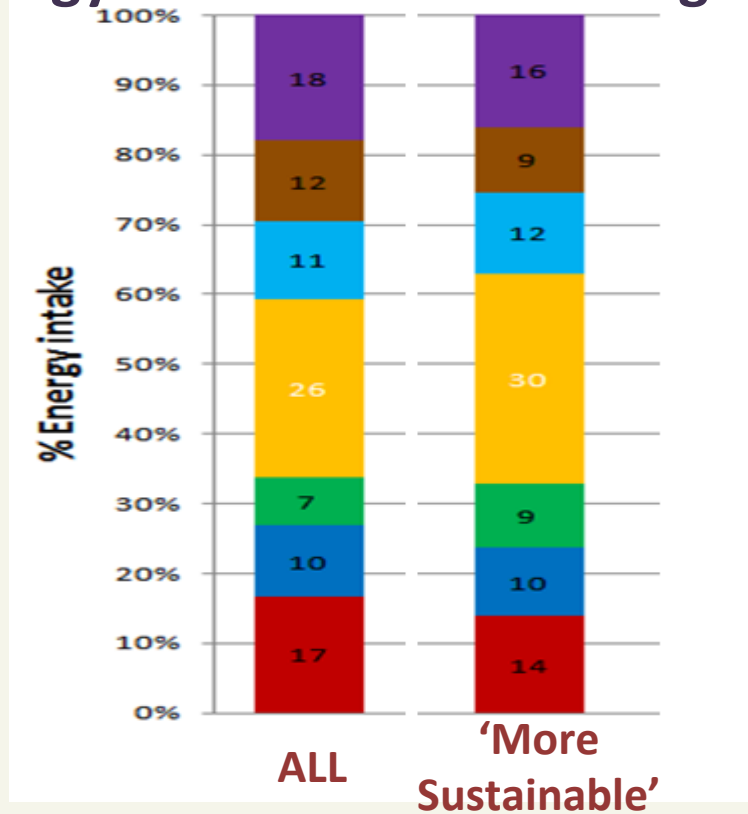
(Masset et al, AJCN 2014)



- 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

Energy contribution of food groups

(Masset et al, AJCN 2014)



- Snacks, sweets, desserts ↓
- Mixed dishes ↓
- Fats, condiments =
- Starchy foods ↑
- Fruit, vegetables, nuts ↑
- Dairy products =
- Meat, fish, eggs ↓

% weight from plants : 53% => 58%

Diet cost : 6,7€/d => 6,2 €/d

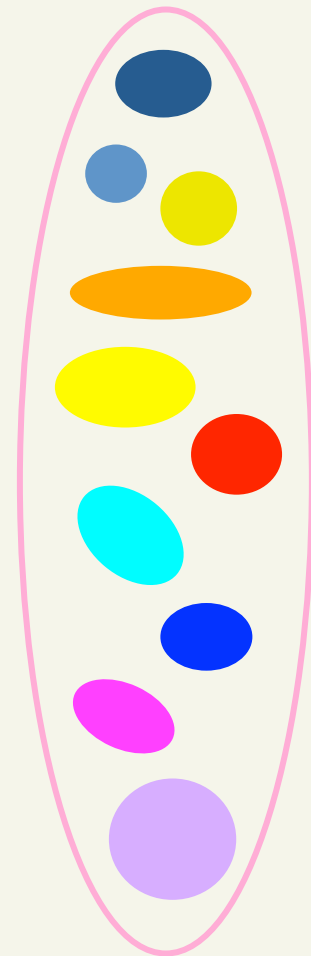
➔ More sustainable self-selected diets (GHGE reduced by 20%): small decrease of animal products and small increase of plant-based products

Is it possible to reduce GHGE by more than 20% while reaching nutritional adequacy?

ANSWER WITH:

→ Diet modeling with linear programming (LP)

Perignon et al, Pub Health Nutr 2016



Observed diet

VARIABLES (Food and their weights)

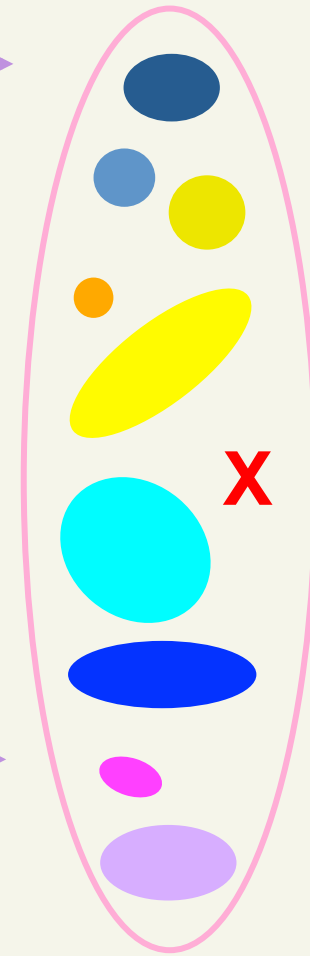
CONSTRAINTS

(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 \leq Observed cost**
- **All nutritional recommendations**

OBJECTIVE FUNCTION

Minimizing departure from the observed diet

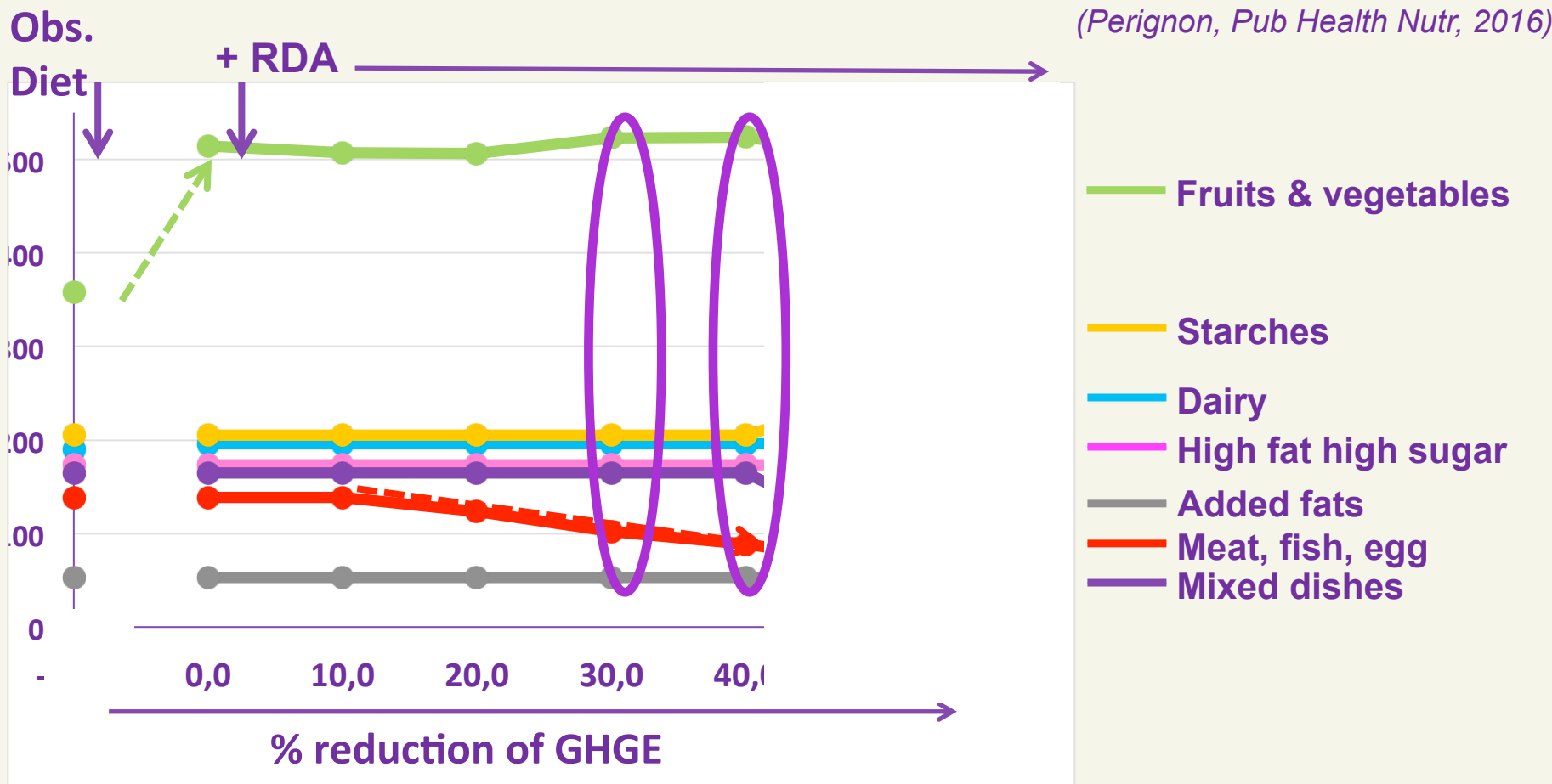


Modeled diet

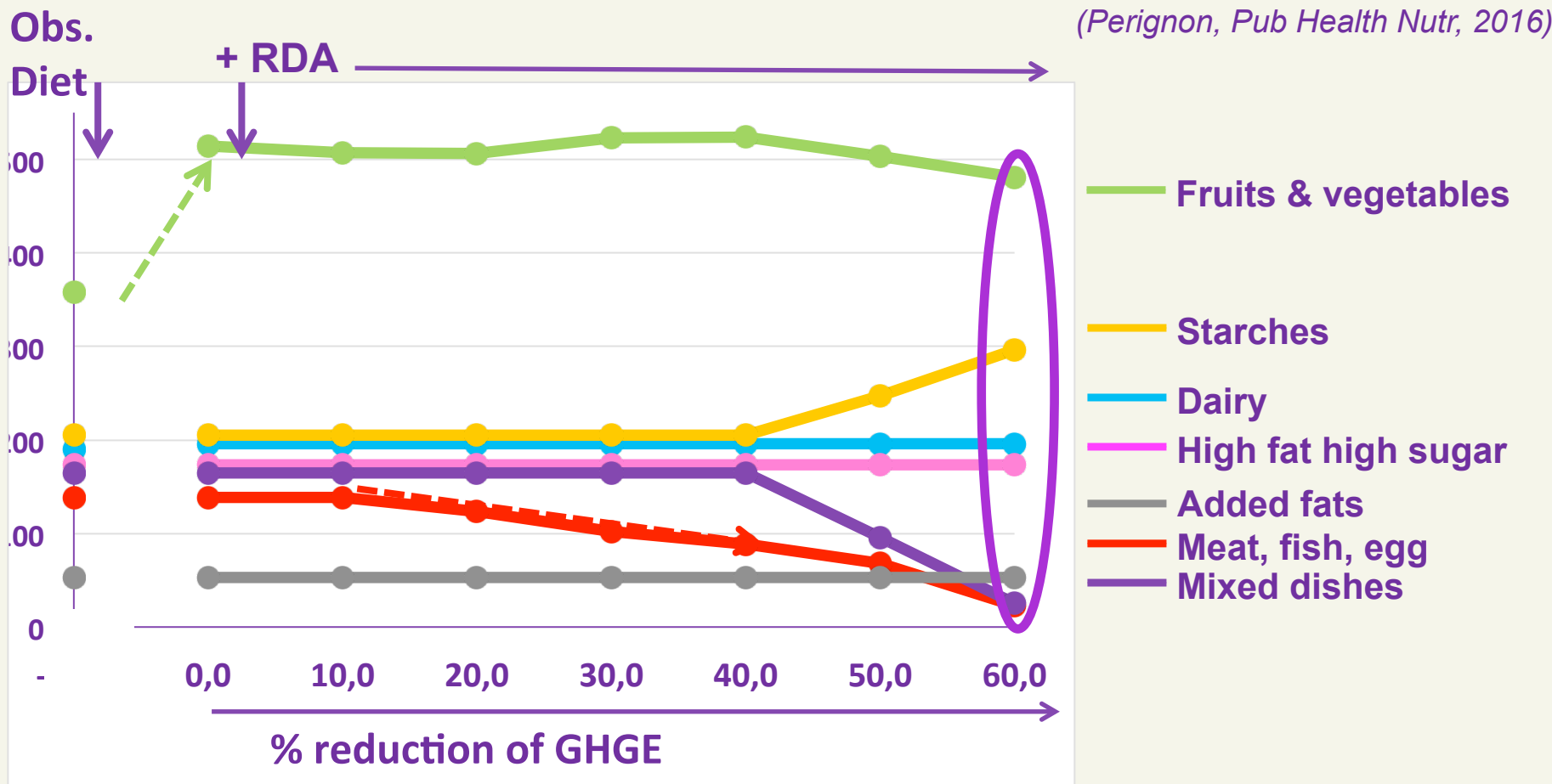
Nutrition
Environment

Economy
Culture

→ The ADEQ model



→ 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)



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

Conclusion

Health & nutrition

*“nutritionally adequate,
safe and healthy”*

Environment

*“protective and respectful of
biodiversity and ecosystems”*

Sustainable Diets

(FAO, 2010)

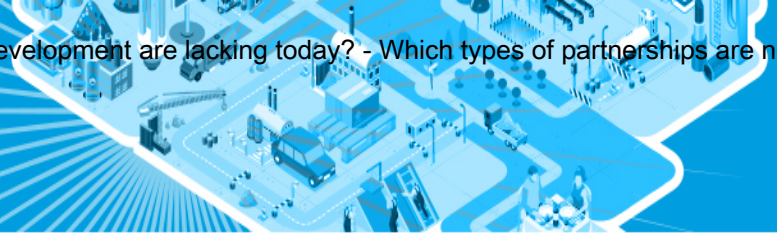
Culture

“culturally acceptable”

Economy

*“accessible, economically
fair and affordable”*

- 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

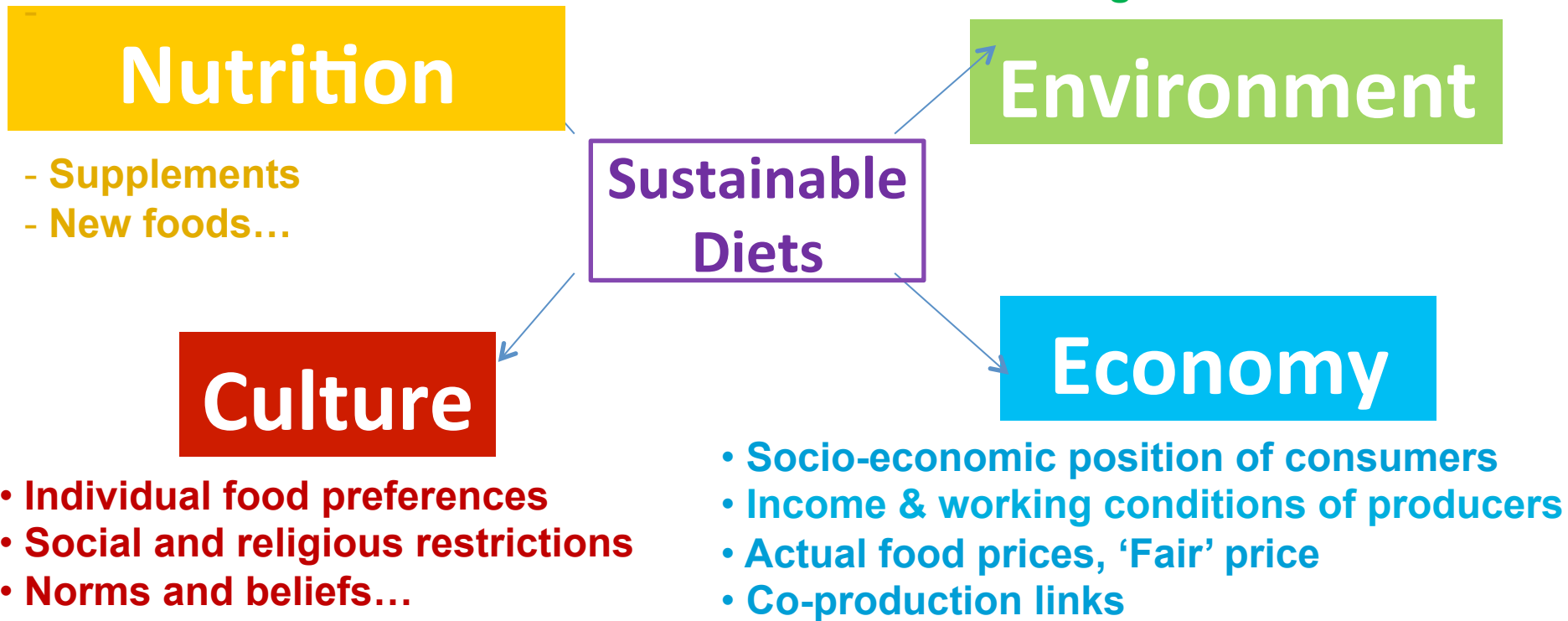


Priority research for the next 10 years? **INTEGRATION**

Which tools for research & development are lacking? **DATABASES**

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

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



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

EUROPEAN WORKSHOP ON
BIOECONOMY

JUNE 28/29TH 2017, PARIS



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...

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



- 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

...

Addressing the limits → Food safety

Which compatibility with nutritional adequacy?

The Journal of Nutrition. First published ahead of print September 14, 2016 as doi: 10.3945/jn.116.234294.

The Journal of Nutrition
Methodology and Mathematical Modeling



Reaching Nutritional Adequacy Does Not Necessarily Increase Exposure to Food Contaminants: Evidence from a Whole-Diet Modeling Approach¹⁻³

Tangui Barré,⁴ Florent Vieux,⁵ Marlène Perignon,⁴ Jean-Pierre Cravedi,⁶ Marie-Josèphe Amiot,⁴ Valérie Micard,⁷ and Nicole Darmon^{4*}

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.

Addressing the limits → Bioavailability

How taking it into account?

- **IRON absorption** → algorithm² taking into account **inhibitors / enhancers** content in diet

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

- **ZINC absorption** → algorithm³ taking into account **inhibitors / enhancers** content in diet

$$TAZ = 0.5 \cdot \left(A_{MAX} + TDZ + K_R \cdot \left(1 + \frac{TDP}{K_P} \right) - \sqrt{\left(A_{MAX} + TDZ + K_R \cdot \left(1 + \frac{TDP}{K_P} \right) \right)^2 - 4 \cdot A_{MAX} \cdot TDZ} \right)$$

*TDZ: Total Dietary Zinc ,
TDP: Total Dietary Phytate,
A_{max}=0.13, K_r=0.10*

- **PROTEIN quality** → score¹ taking into account **amino acid content and protein digestibility**

Protein Digestibility Corrected Amino Acid Score (**PDCAAS**) =
% digestibility x amino acid score

References:

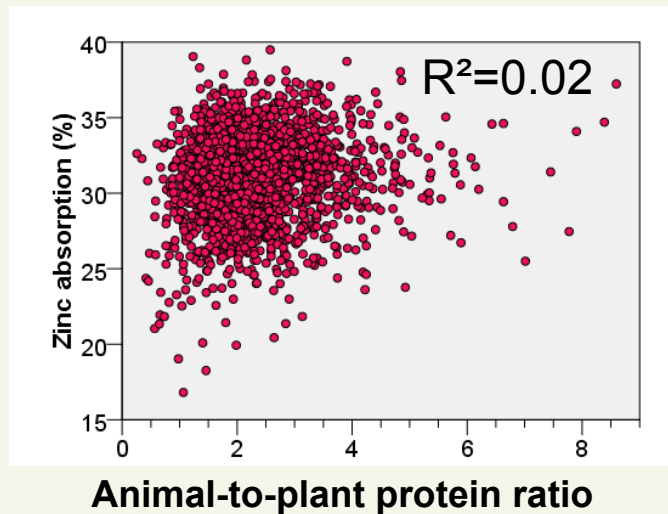
- ¹FAO/WHO/UNU Expert Consultation (2007). Protein and amino acid requirements in human nutrition: joint FAO/WHO/UNU expert consultation
- ²Armah et al. (2013). A complete diet-based algorithm for predicting nonheme iron absorption in adults. *The Journal of nutrition*, 143(7), 1136–40
- ³Miller et al. (2007). A mathematical model of zinc absorption in humans as a function of dietary zinc and phytate. *J Nutr*, 137(1), 135–41

Addressing the limits → Bioavailability

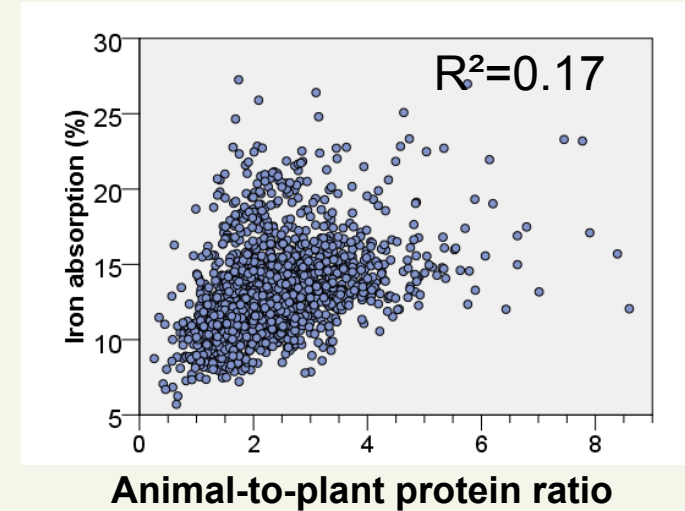
FIRST RESULTS:

(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