

**South African Society of Dairy Technology**

**Symposium 2025**

**DAIRY RESEARCH SUSTAINABLE DIETS: NUTRITIONAL LCAs**

**Dr. Stephan Peters – Dutch Dairy Association**

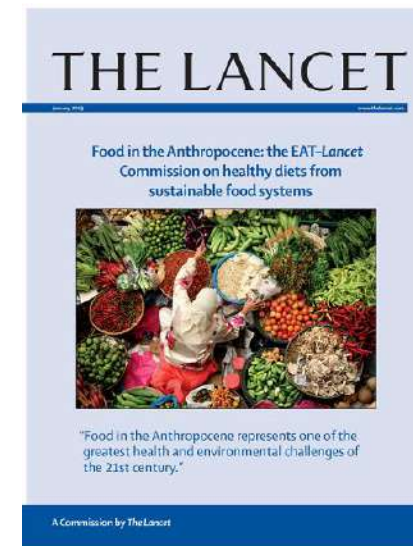
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Plant-based diets  
=  
Less animal sourced?



# DISCLOSURE:





# NUTRITION STATUS OF SOUTH AFRICANS

## PERSISTENT DOUBLE BURDEN OF DISEASE

### UNDERNUTRITION, DEFICIENCY & HUNGER

Infants:

- 14% low birth weight
- 32% breastfed until 6 months
- 27% stunted

Deficiencies in children:

- Vitamin A 44%
- Iron 10%
- Zinc 45%
- Minimum acceptable diet - only 23%

Iron deficiency in women:

- 24% adolescents
- 31% women

Hunger:

- 19% moderate or severe food insecurity
- Undernourished people doubled since 2006

### OVERNUTRITION & NON-COMMUNICABLE DISEASE (NCD)

Most obese country in Sub-Saharan Africa

- 68% women overweight or obese
- 11% adolescents overweight
- Childhood overweight double the global average (13%)

Premature death rate from NCDs 59%

- Hypertension 45%
- Diabetes 13%



# NUTRITION STATUS OF SOUTH AFRICANS: DOUBLE CLICK ON CALCIUM



Average calcium intake in SA ~  
**400-500mg/day** (versus  
1000mg/day RDI for adults)

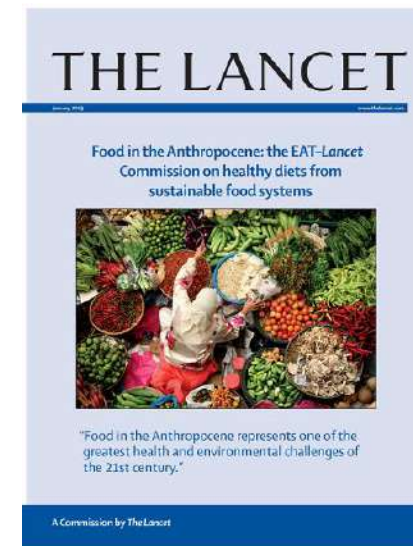
**13.2% children** with abnormally  
low blood calcium levels

Africa (continent) registers **highest  
rate of rickets worldwide.**

Source: National Osteoporosis  
Foundation – South Africa



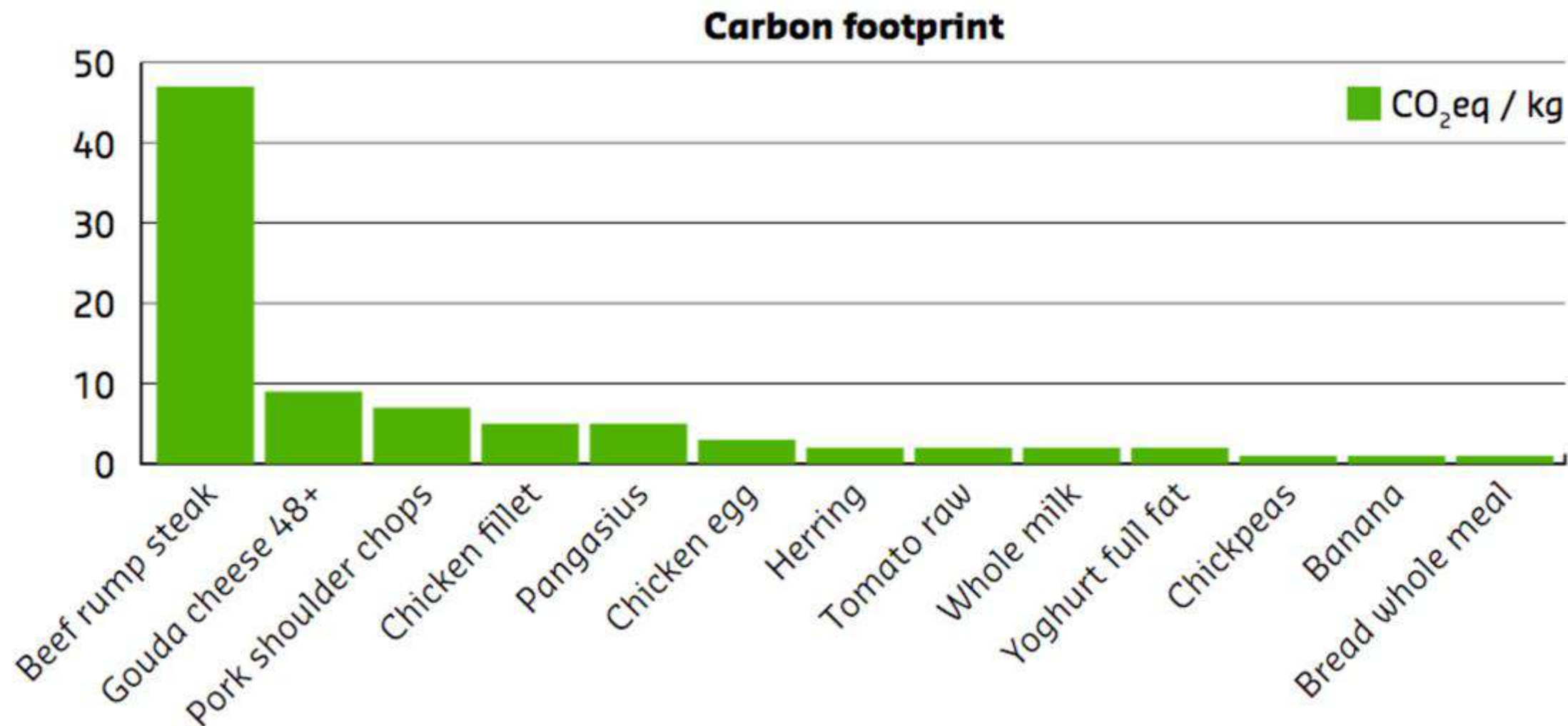
Plant-based diets  
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Less animal sourced



# Life-Cycle Assessment (LCA)







# Future-proof and sustainable healthy diets based on current eating patterns in the Netherlands

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## ABSTRACT

**Background:** To keep global warming <1.5°C as recommended by the Intergovernmental Panel on Climate Change (IPCC), eating patterns must change. However, future diets should be modeled at a national level and respect cultural acceptability.

**Objectives:** We aimed to identify diets among Dutch adults satisfying nutritional and selected environmental requirements while deviating minimally from the baseline diet among Dutch adults.

**Methods:** We calculated per capita food system greenhouse gas emission (GHGE) targets derived from the IPCC 1.5-degree assessment study. Using individual adult dietary intake from the National Food Consumption Survey in the Netherlands (2007–2010) to form a baseline, we used quadratic optimization to generate diets that followed the baseline Dutch diet as closely as possible, while satisfying nutritional goals and remaining below GHGE targets. We considered 12 scenarios in which we varied GHGE targets [2050: 1.11 kg of carbon dioxide equivalent (kg CO<sub>2</sub>-eq) per person per

**Keywords:** sustainability, dietary scenarios, health impact, environmental impact, dietary change

## Introduction

Food systems are important contributors to global greenhouse gas emissions (GHGEs), as well as to land occupation and degradation, biodiversity loss, nutrient flow disruption, freshwater depletion, and depletion of fossil fuels (1, 2). To meet the 2030 and 2050 GHGE targets of the Paris Agreement or the Intergovernmental Panel on Climate Change (IPCC) report (3), transitions are needed in food systems and diets.

A global reference diet that considers the health and environmental sustainability aspects of eating patterns was recently published in the EAT–Lancet report (4). The authors call for country-specific analyses, using individual consumption data if possible, while staying in line with their proposed global

Food group	Baseline diet among Dutch adults	No- GHGE- target scenario	Relaxed GHGE- target scenario	2030 scenario (sensitivity range <sup>2)</sup>	2050 scenario
Dairy foods					
Cheese	39	26	19	3 (0, 10)	0
Liquid dairy	371	364	368	363 (348, 376)	128
Butter	6	0	0	0 (0, 0)	0
Beef and lamb	44	37	0	0 (0, 0)	0
Chicken and other poultry	30	26	22	11 (5, 17)	0
Pork	56	24	17	10 (5, 19)	0



The results of this study suggest that the 2030 food system GHGE target cannot be achieved by only correcting nutritional inadequacies, indicating that additional dietary changes are needed. We do show, however, that it is possible to meet the 2030 and 2050 GHGE targets, but large shifts in diets might be needed and the feasibility of those changes may be limited. Our

sustainable diets (59).

Modeling diets for 2050 was technically feasible, but the solutions in this scenario lacked food diversity and deviated greatly from baseline eating patterns. Results showed that

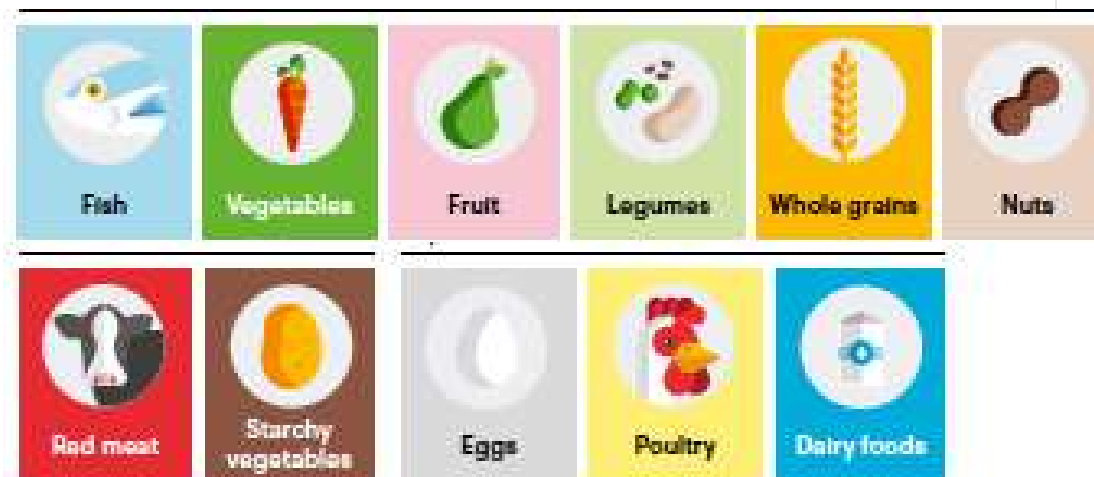
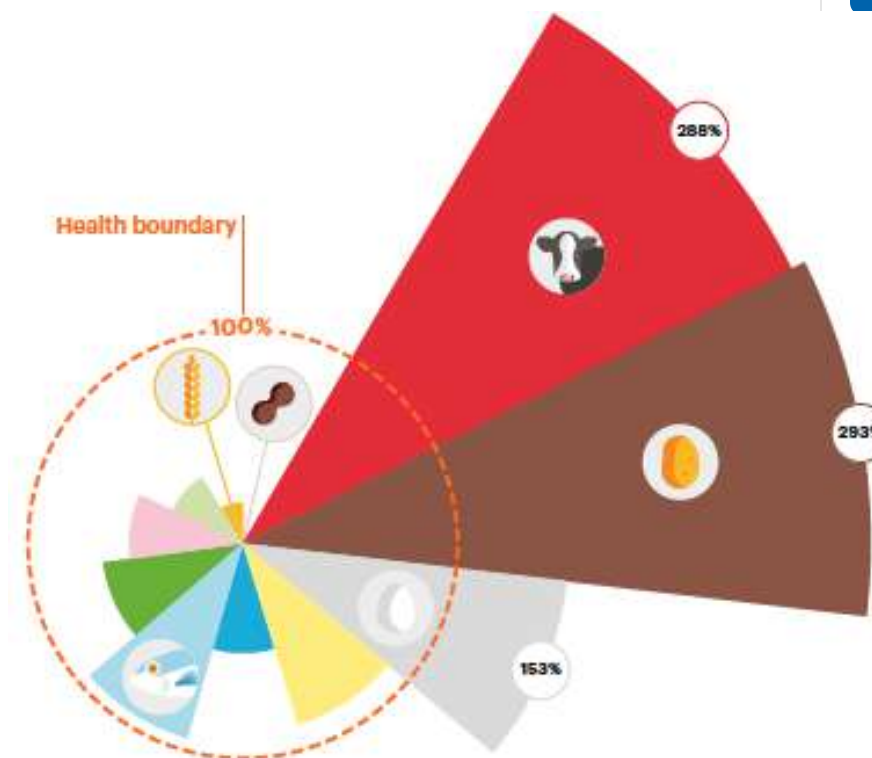
nutritional adequacy for essential fats, fatty acids, and vitamins  
by 2050, and by 2050, many nutrient groups were missing 10-20%  
of the baseline diet among Dutch adults. The optimized solution  
complying to the lowest GHGE target (2050) lacked food diversity,  
and the (lacto-ovo) vegetarian and vegan optimized diets were prone  
to nutritional inadequacies.

Conclusion: Within Dutch eating habits, achieving nutrition  
Twitter @StephanPetersNL

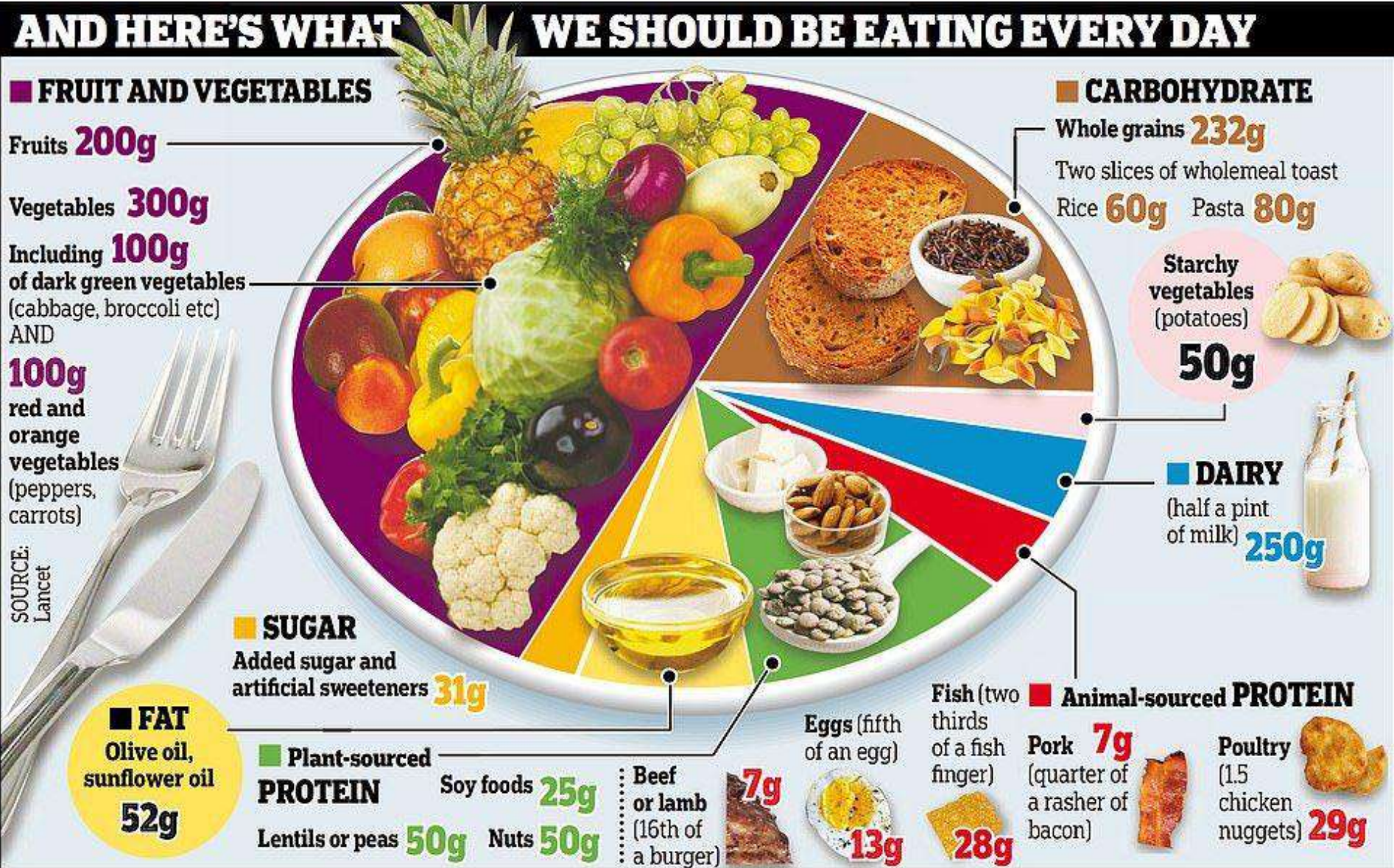


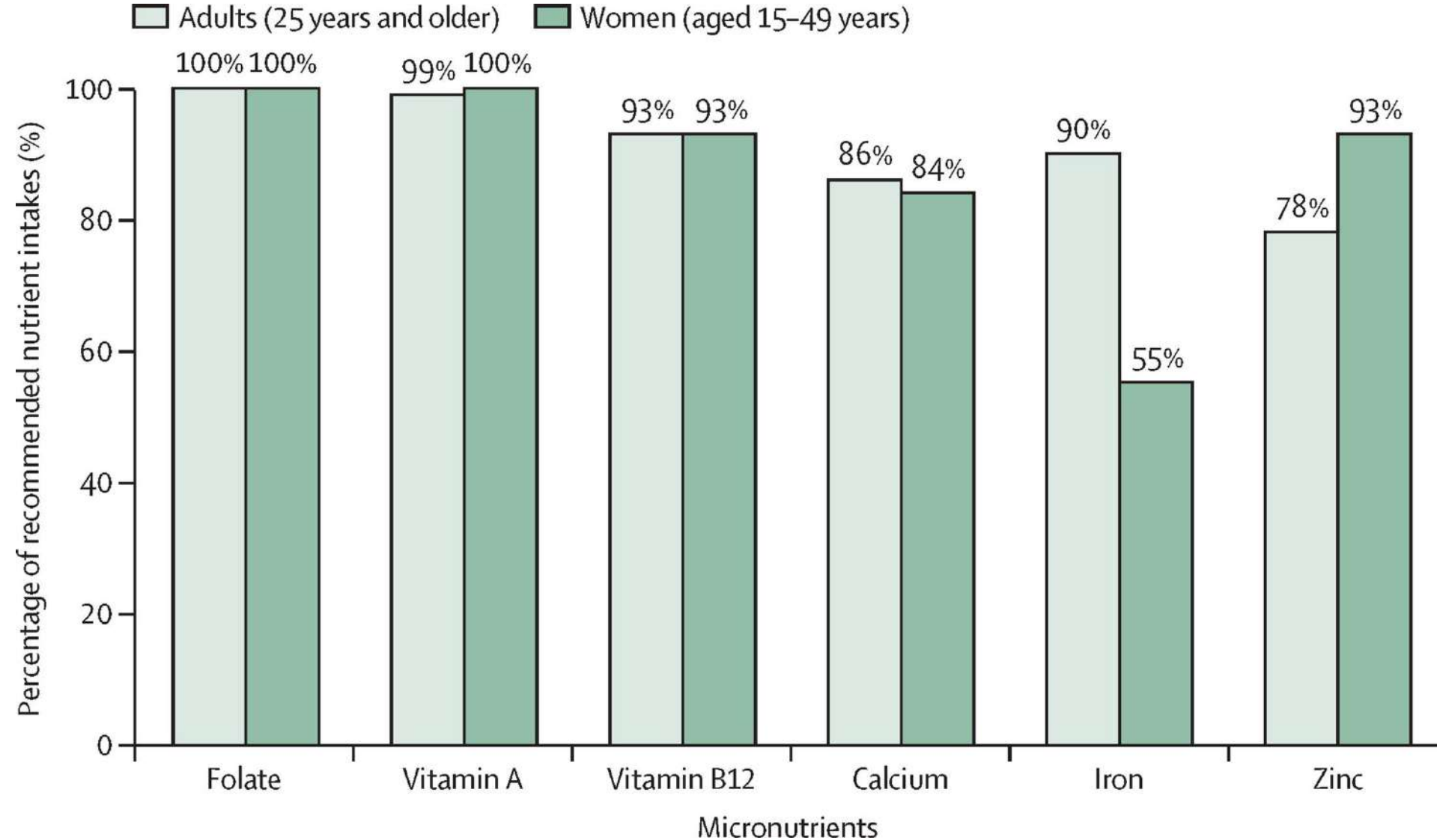
# EAT-Lancet

	Macronutrient intake grams per day (possible range)	Caloric intake kcal per day
 Whole grains Rice, wheat, corn and other	232	811
 Tubers or starchy vegetables Potatoes and cassava	50 (0-100)	39
 Vegetables All vegetables	300 (200-600)	78
 Fruits All fruits	200 (100-300)	128
 Dairy foods Whole milk or equivalents	250 (0-500)	153
<b>Protein sources</b>		
 Beef, lamb and pork	14 (0-28)	30
 Chicken and other poultry	29 (0-58)	62
 Eggs	13 (0-25)	19
 Fish	28 (0-100)	40
 Legumes	75 (0-100)	284
 Nuts	50 (0-75)	291
<b>Added fats</b>		
 Unsaturated oils	40 (20-80)	354
 Saturated oils	11.8 (0-11.8)	96
<b>Added sugars</b>		
 All sugars	31 (0-31)	120









# Average dairy intake South Africa: 110 g/day

- The average calcium intake in South Africa is approximately 400-500mg/day. This is significantly lower than the recommended daily intake of 1000mg/day for adults.
- 13.2% of children have abnormally low levels of calcium in their blood.
- Africa (continent) registers the **highest rate of rickets** (a condition that affects bone development in children associated with low calcium and vitamine D) worldwide.

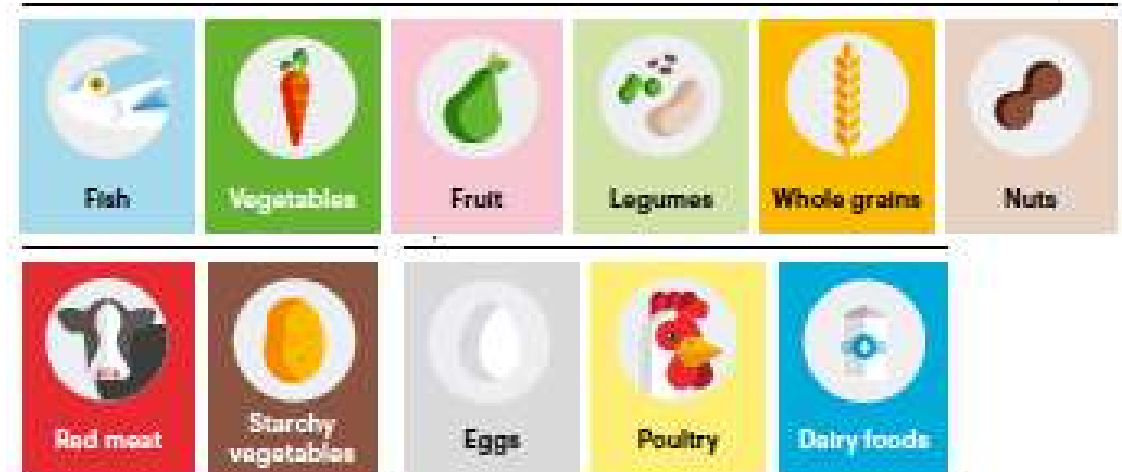
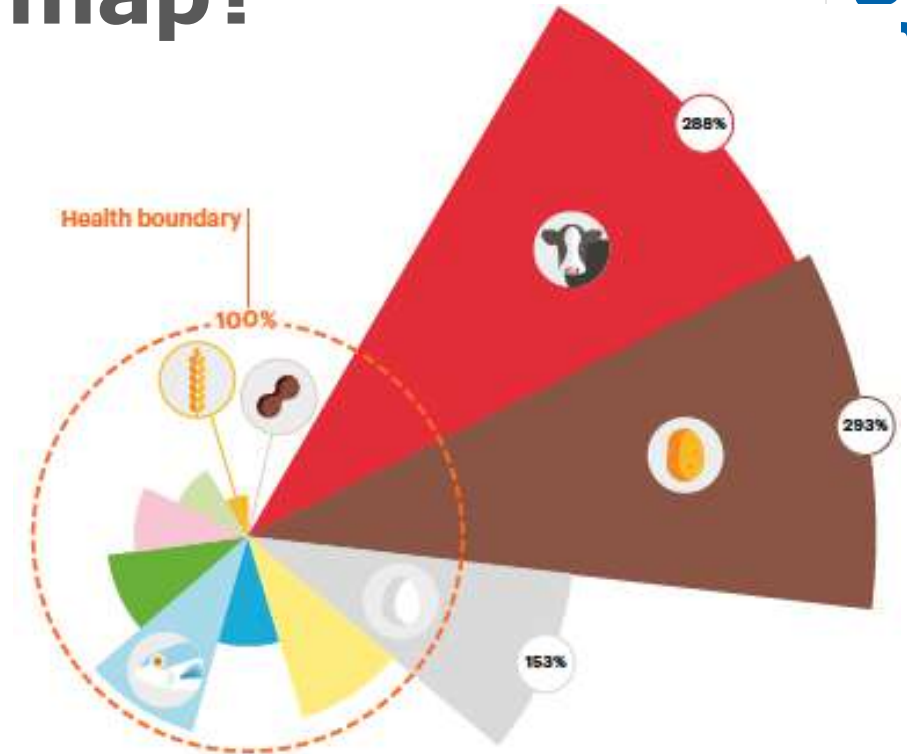


Source: National Osteoporosis Foundation – South Afrika



# EAT-Lancet: picture or a roadmap?

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# The destination can be beautiful, but the journey might be challenging without a roadmap



# How to balance nutritional value and environmental impact







Markt



Kwaliteit

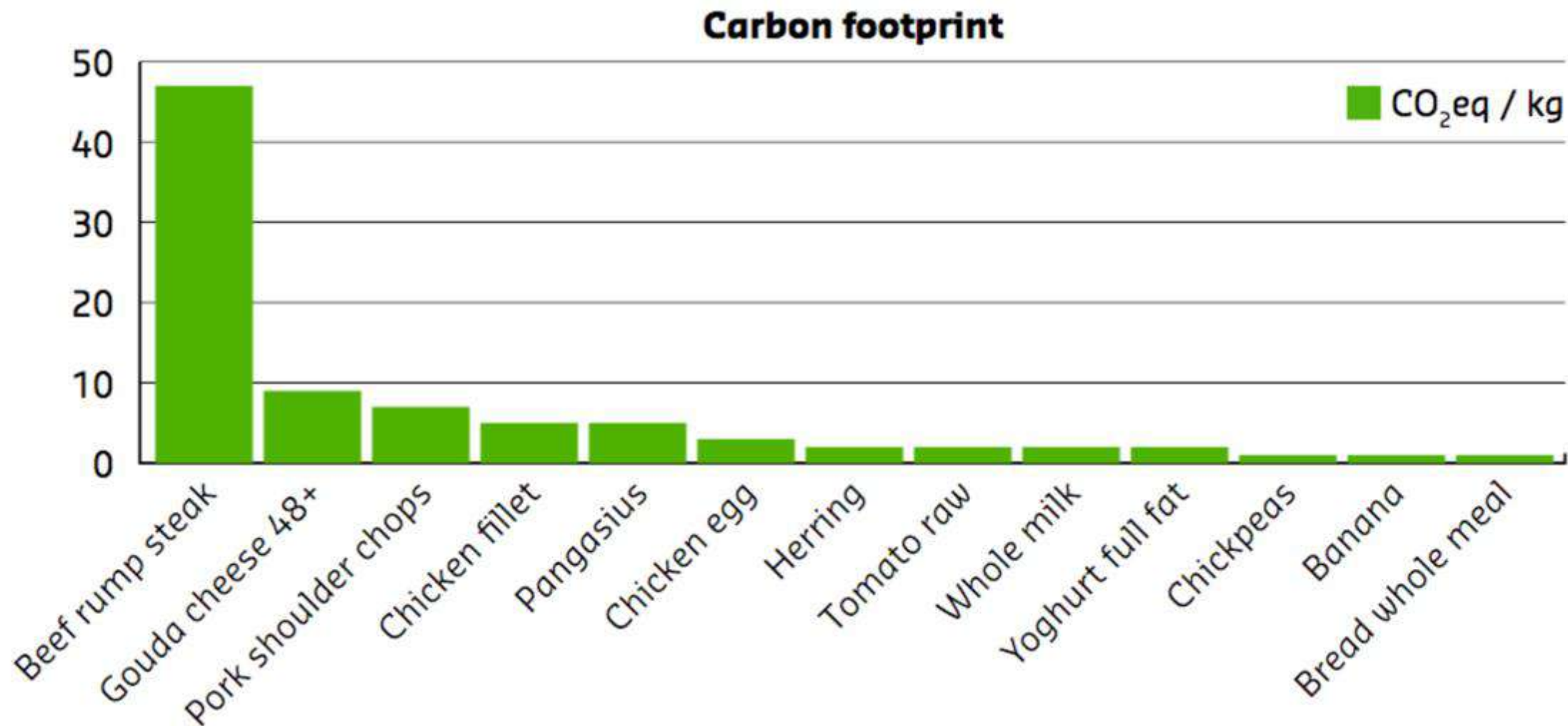


Voeding



Duurzaam





## Voeding

FAO: nutritional LCA (nLCA)



Food and Agriculture  
Organization of the  
United Nations

### Integration of environment and nutrition in life cycle assessment of food items: opportunities and challenges



- <2020: **LCA = CO<sub>2</sub>/kg** translated to food-based dietary guidelines
- 2021: FAO report recognition nutritional LCA: **nLCA = LCA/nutrients**
- 2025:

$$\mathbf{QI-nLCA = LCA/QI}$$

$$\text{LCA} = \text{CO}_2/\text{kg}$$

$$\text{nLCA} = \text{CO}_2/\text{nutrients}$$

$$\text{QI} = 21 \text{ nutrients} / \text{kcal}$$

$$\mathbf{QI-nLCA = CO_2/kg \over QI}$$



$$QI = \frac{E_d}{E_p} * \frac{\sum_{j=1}^{N_q} \frac{a_{q,j}}{r_{q,j}}}{N_q}$$

Where:

$E_d$  = average daily energy needs of the population group (kcal)

$E_p$  = energy in the amount of food analyzed (kcal)

$a_{q,j}$  = amount of qualifying nutrients in the amount of food analyzed (g, mg or  $\mu\text{g}$ )

$r_{q,j}$  = RDI of qualifying nutrients (g, mg or  $\mu\text{g/day}$ )

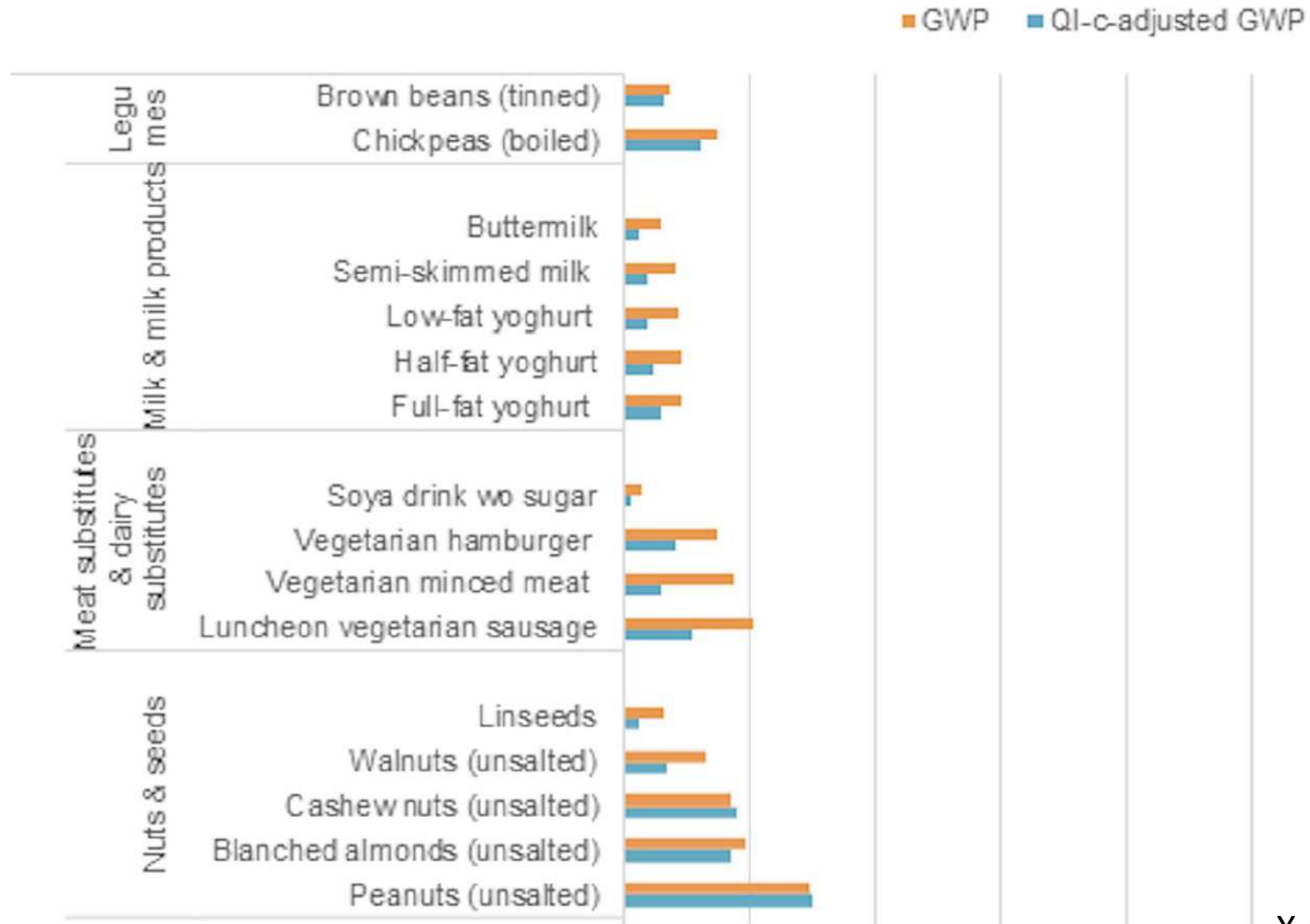
$N_q$  = number of qualifying nutrients considered

QI = 21 nutrients / kcal

$$\text{QI-nLCA} = \frac{\text{CO}_2/\text{kg}}{\text{QI}}$$

# Voeding

LCA adjusted for QI



X @StephanPetersNL



Food group	Food	QI-c <sup>#</sup>	GWP (kg CO <sub>2</sub> eq/kg)	QI-c-adjusted GWP (kg CO <sub>2</sub> eq/kg)
Pastry and biscuits	Syrup waffle	0.28	3.86	13.99
	Dutch spiced cake	0.34	1.35	3.98
	Fruit biscuits	0.34	2.72	7.95
	Biscuits	0.36	3.10	8.74
	Almond paste filled tarts	0.39	3.91	10.12
	Cake (with butter)	0.40	5.75	14.26
	Appel pie (with butter)	0.40	3.53	8.73
	Wholemeal biscuits	0.51	3.53	6.93
	Apple pie (without butter)	0.58	2.29	3.93
	Cake (without butter)	0.62	3.27	5.28
Savory snacks	Popcorn without oil	0.60	0.95	1.58
	Sausage <u>roll</u> puff pastry	0.71	5.40	7.56
	Potato crisps	0.74	4.83	6.51
	Meat croquette	0.76	8.11	10.71
	Dutch sausage (" <i>frikandel</i> ")	1.08	5.18	4.81

<sup>#</sup> QI-c: Qualifying Index with capping. Capping was done on a 100-kcal basis (i.e. nutrient values > RDI at 100 kcal of product were truncated to RDI values).

Meal component	Portion size (kg)	GWP per portion (kg CO <sub>2</sub> eq)	GWP per portion, adjusted for QI-c (kg CO <sub>2</sub> eq)	GWP per portion, adjusted for food-group-specific QI-c (kg CO <sub>2</sub> eq)
French beans	0.25	0.27	0.06	0.03
Boiled potatoes	0.28	0.26	0.22	0.18
Chicken fillet	0.10	1.09	0.50	0.41
Yoghurt	0.15	0.35	0.23	0.17
Strawberries	0.10	0.64	0.20	0.10
<i>TOTAL</i>	<i>0.88</i>	<i>2.61</i>	<i>1.21</i>	<i>0.89</i>

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LCIA OF IMPACTS ON HUMAN HEALTH AND ECOSYSTEMS



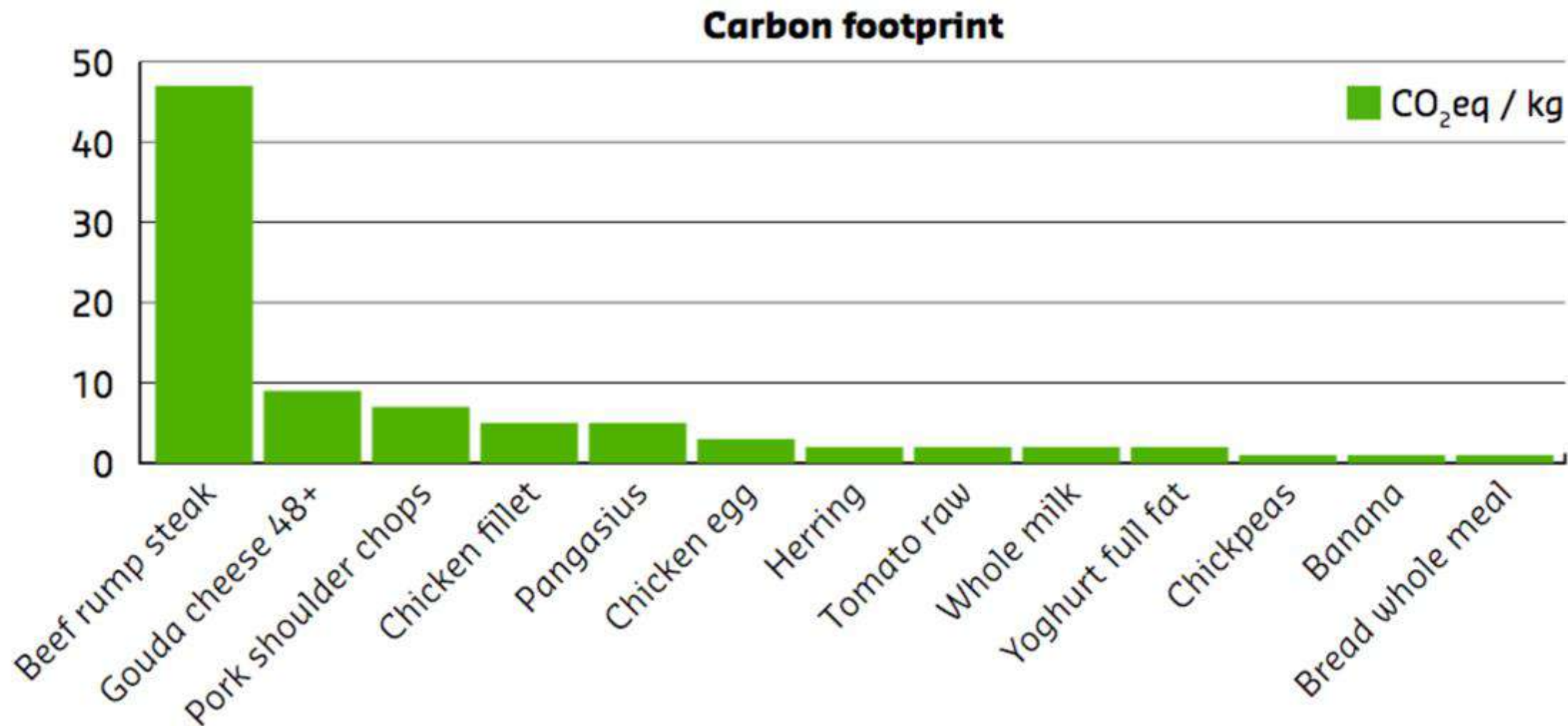
# Combining nutritional value with environmental impact: a novel approach to nutritional life cycle assessment

Manon van Eijsden<sup>1</sup> · Stephan Peters<sup>2</sup>  · Olaf F. A. Larsen<sup>3,4</sup> · Jan M. W. Geurts<sup>5</sup> · Thom Huppertz<sup>5,6</sup>

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## Voeding

# It's not that easy to replace nutrients from animal products

- Dairy meat and eggs are major sources of many nutrients in the Dutch diet
- >50% of dietary intake from animal products:
  - Calcium
  - Phosphorus
  - Selenium
  - Zinc
  - Retinol
  - Vitamin B2
  - Vitamin B12
- Not as easy to replace by other products
- And replacement diets are not always logical



### Sources of minerals

Food Consumption Survey 2012-2016, ages 1-29

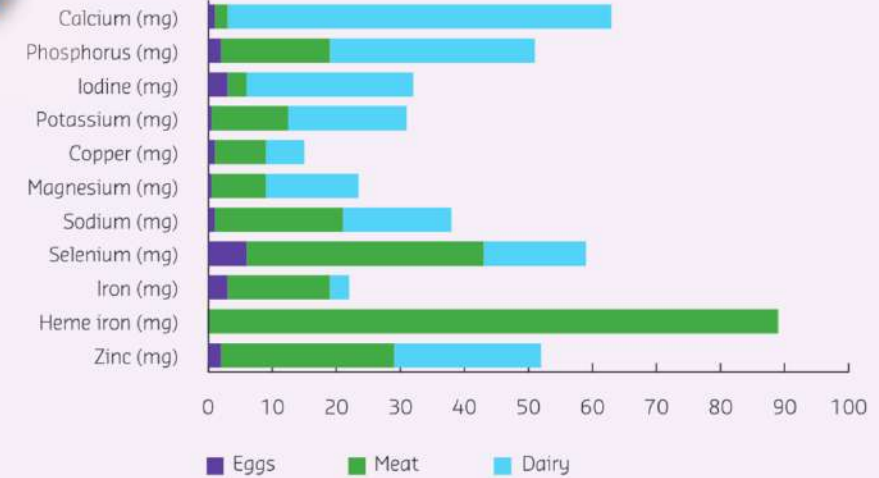


Figure 1a. Share of eggs (green), meat (orange) and dairy (blue) in the average Dutch person's (ages 1-79) mineral intake according to the RIVM Food Consumption Survey, 2012-2016.

### Sources of vitamins

Food Consumption Survey 2012-2016, ages 1-29

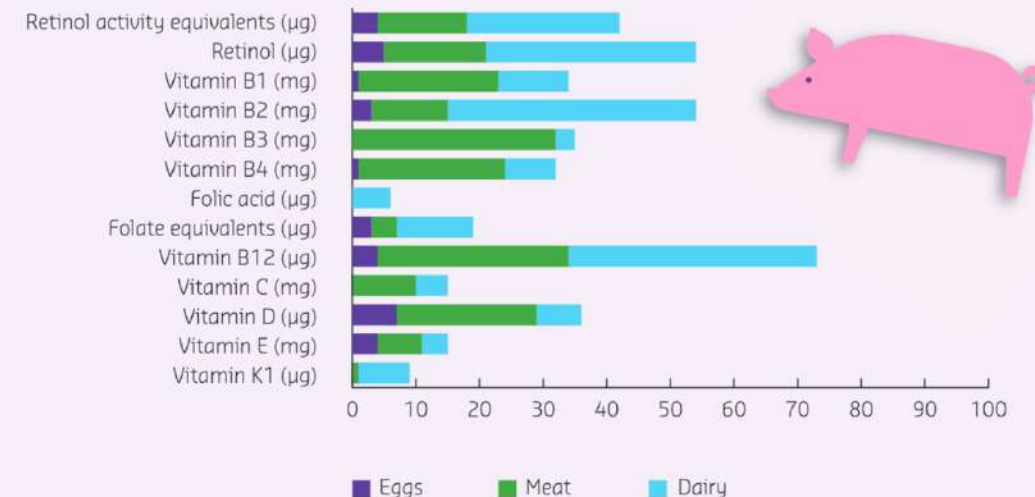
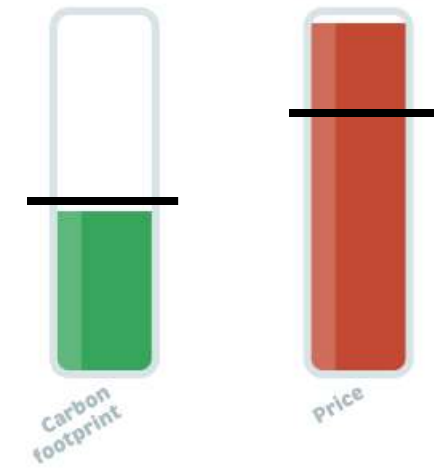
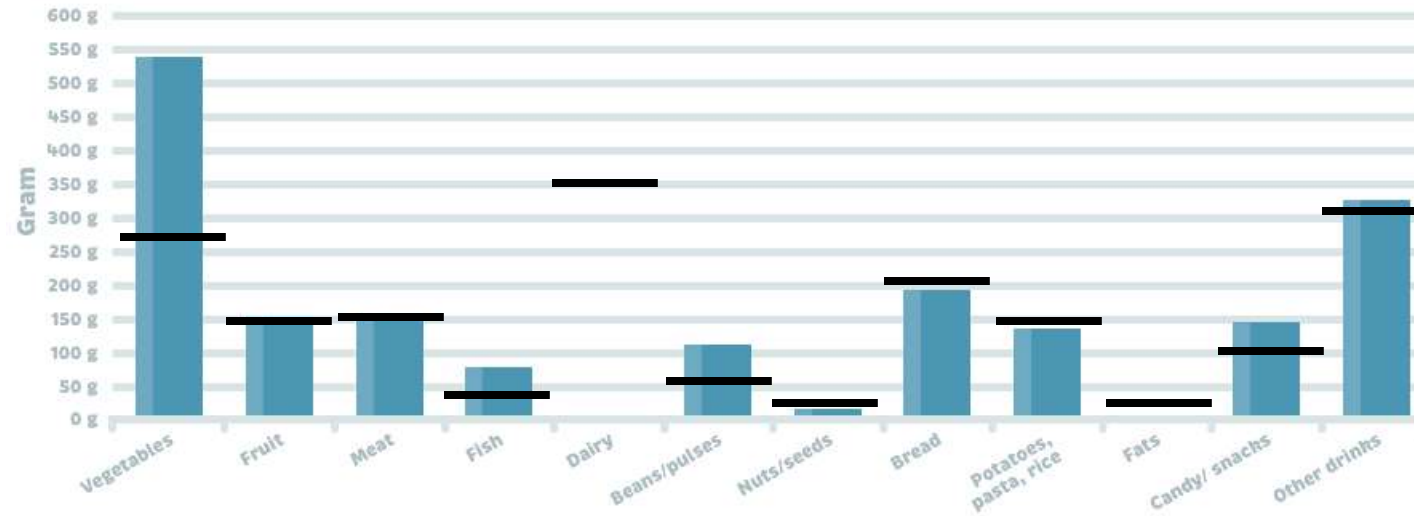


Figure 1b. Share of eggs (green), meat (orange) and dairy (blue) in the average Dutch person's (ages 1-79) vitamin intake according to the RIVM Food Consumption Survey, 2012-2016.

# Voeding What has changed after removing all dairy?



Removal of dairy results in:

- Hardly any change in carbon footprint!
- Large increase in price!
- >2-fold increase in vegetable intake (>500 g per day!) but no change in fruit
- Increase in fish, beans and pulses and candy and snacks
- Limited change in other food groups



Markt



Kwaliteit



Voeding



Duurzaam





*nutrients*



*Article*

# Exploring Nutrient-Adequate Sustainable Diet Scenarios That Are Plant-Based but Animal-Optimized

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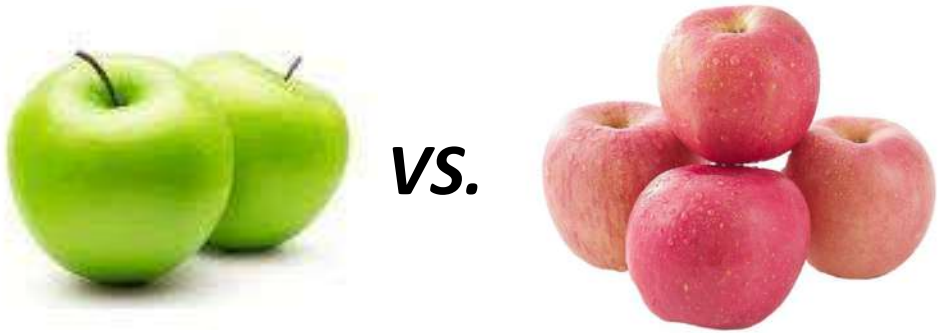
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<sup>5</sup> Nederlandse Zuivel Organisatie (NZO), 2596 BC The Hague, The Netherlands; [peters@nzo.nl](mailto:peters@nzo.nl)

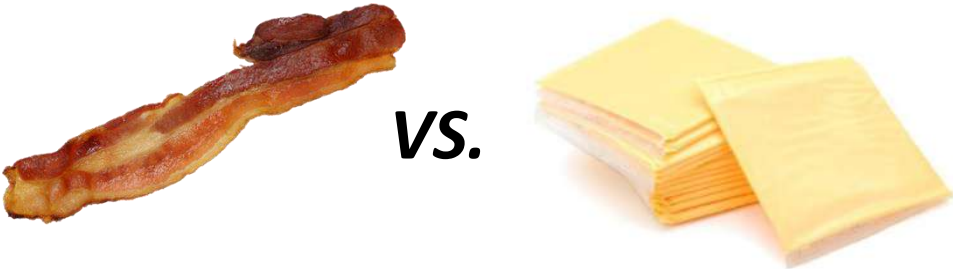
\* Correspondence: [thom.huppertz@wur.nl](mailto:thom.huppertz@wur.nl) or [thom.huppertz@ucc.ie](mailto:thom.huppertz@ucc.ie)

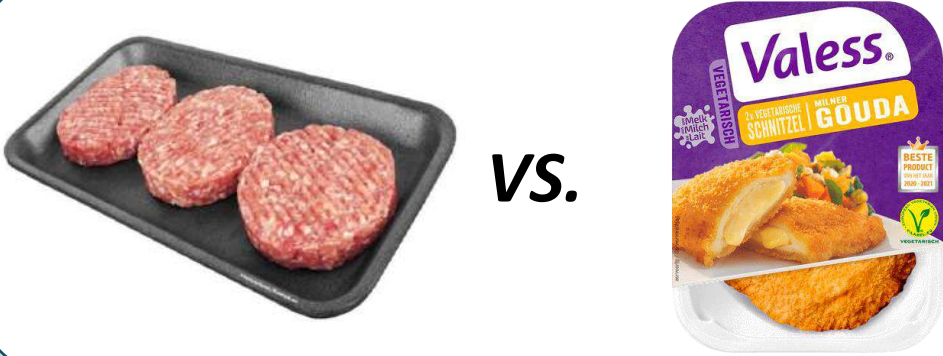
Food item	Type of food	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> eq/	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> e/ 100 kcal	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> e/
							
Ham sh...							
Beef rum...							
Potatoes							
Eggs (chi...							
Chicken v...							
Milk who...							
Milk skim...							
Cheese Gouda 40+ average	Dairy	1.31	0.26	2.16	0.36	3.74	0.04
Shrimps Dutch peeled boiled	Fish	1.54	0.15	6.39	1.64	7.78	1.22
Herring salted	Fish	0.28	0.21	0.84	0.16	1.59	0.32

Food item	Type of food	kg CO <sub>2</sub>	kg CO <sub>2</sub>	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> e/	kg CO <sub>2</sub>	kg CO <sub>2</sub> e/NRF 20.3
							
Ham sh...							68
Beef rum...							02
Potatoes							05
Eggs (chi...							14
Chicken v...							74
Milk who...							34
Milk skim...							30
Cheese Gouda 40+ average	Dairy	0.70	1.70	1.70	0.41	0.32	0.47
Shrimps Dutch peeled boiled	Fish	2.91	2.19	2.20	0.19	0.20	0.19
Herring salted	Fish	0.56	1.34	1.34	0.06	0.05	0.05

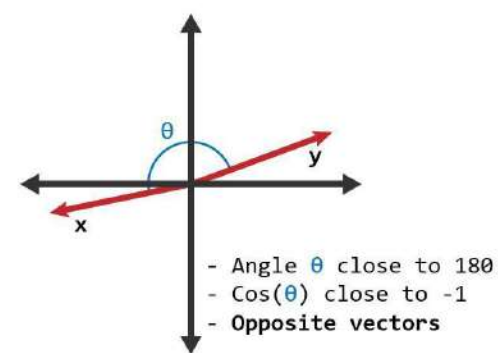
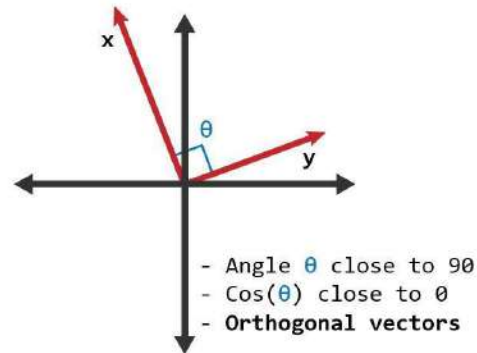
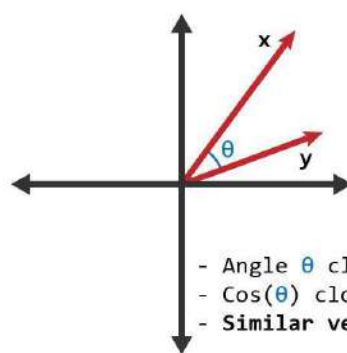
# When are product comparisons valid?

## Similarity Index

							
Apple pie Dutch w shortbread w margarine	Sweets	0.23	0.23	0.39	0.08	6.53	0.35
Almond							
Crisps							
Wine red							
Wine wh							
Peanut b							
Sauce fo							
Juice ap							
Juice ora							
Sausage							
Bacon ra							
Oil olive							
Oil sunflower seed	Oils	0.50	0.05	0.50	0.06	167.02	NA*

							
Apple pie Dutch w shortbread w margarine	Sweets	0.71	NA	NA	0.37	0.80	0.51
Almond							0.95
Crisps							13
Wine red							23
Wine wh							69
Peanut b							17
Sauce fo							14
Juice ap							A
Juice ora							11
Sausage							03
Bacon ra							67
Oil olive							0.16
Oil sunflower seed	Oils	95.20	0.09	0.09	0.08	0.07	0.04

Food item	Type of food	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> eq/	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> e/ 100 kcal	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> e/	Food item	Type of food	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> eq/	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> e/ 100 kcal	kg CO <sub>2</sub> e/	kg CO <sub>2</sub> e/
Har...															
Bee...															
Pot...															
Egg...															
Chi...															
Milk...															
Milk...															
Cheese Gouda 40+ average	Dairy	1.31	0.26	2.16	0.36	5.74	0.04	Shrimps Dutch peeled boiled	Fish	2.91	2.19	2.20	0.19	0.20	0.19
Shrimps Dutch peeled boiled	Fish	1.54	0.15	6.39	1.64	7.78	1.22	Herring salted	Fish	0.56	1.34	1.34	0.06	0.05	0.05
Herring salted	Fish	0.28	0.21	0.84	0.16	1.59	0.32								



# Validation of product comparisons: similarity index calculation

Apple pie Dutch w shortbread w margarine	Sweets	0.23	0.23	0.39	0.08	6.53	0.35	Apple pie Dutch w shortbread w margarine	Sweets	0.71	NA	NA	0.37	0.80	0.51
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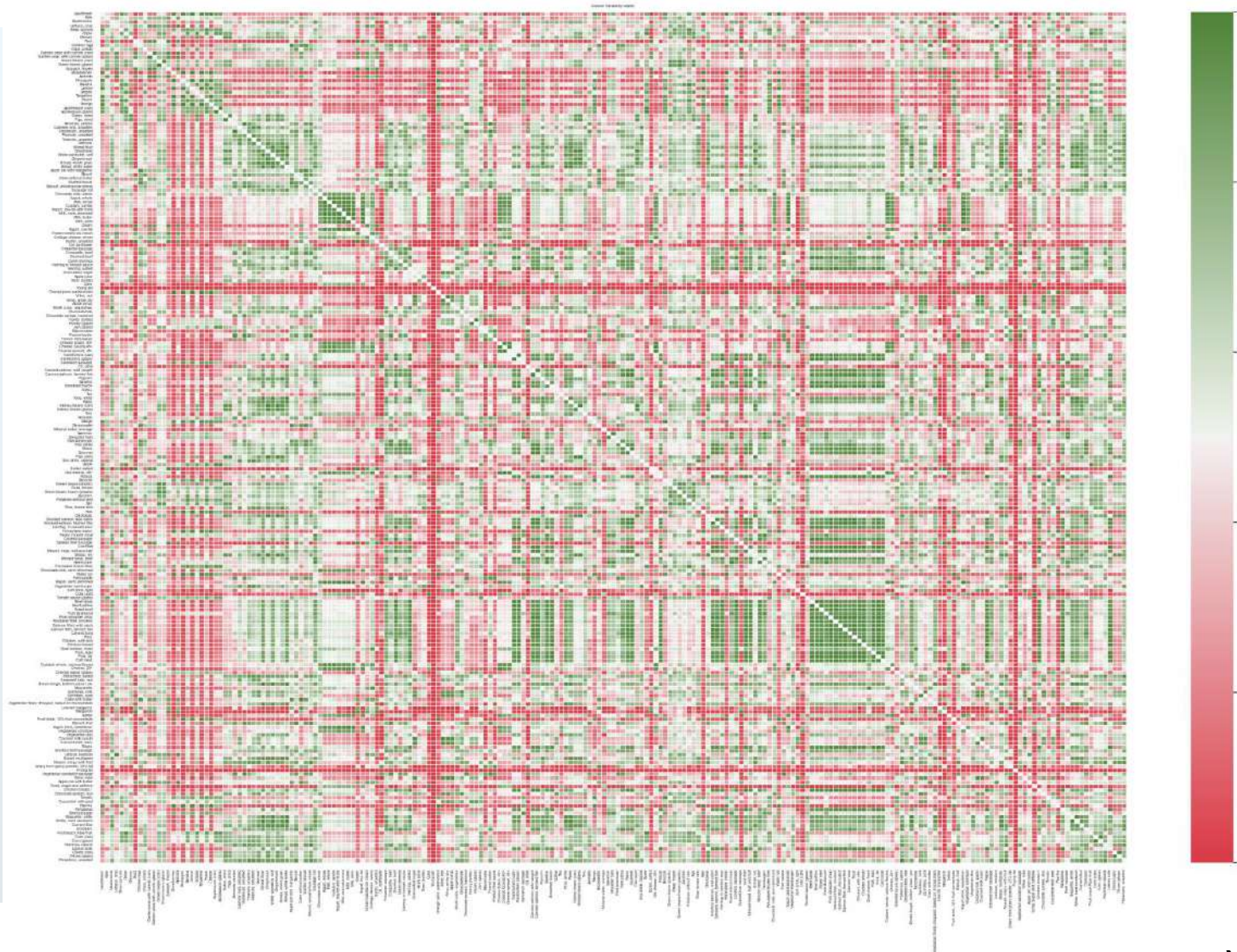
$$\text{cosine similarity} = S_C(A, B) := \cos(\theta) = \frac{\mathbf{A} \cdot \mathbf{B}}{\|\mathbf{A}\| \|\mathbf{B}\|} = \frac{\sum_{i=1}^n A_i B_i}{\sqrt{\sum_{i=1}^n A_i^2} \sqrt{\sum_{i=1}^n B_i^2}},$$

Oil olive	Oils	0.72	0.07	0.72	0.00	NA	NA	Oil olive	Oils	143.44	NA	NA	1.07	0.21	0.10
Oil sunflower seed	Oils	0.50	0.05	0.50	0.06	167.02	NA*	Oil sunflower seed	Oils	95.20	0.09	0.09	0.08	0.07	0.04



# Voeding

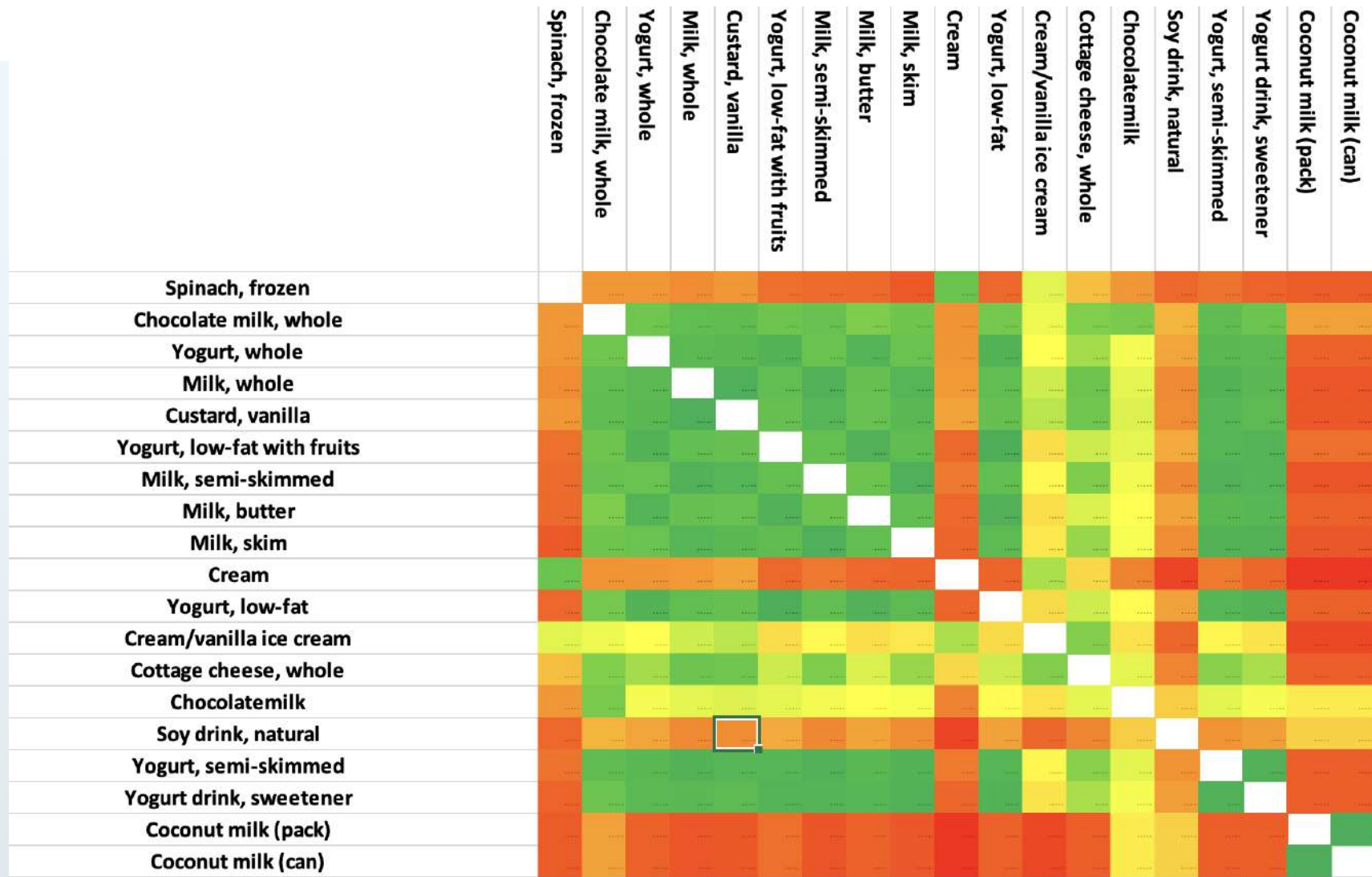
## 6. nLCA: Similarity Index





# Voeding

## Similarity index dairy versus soy drink and spinach

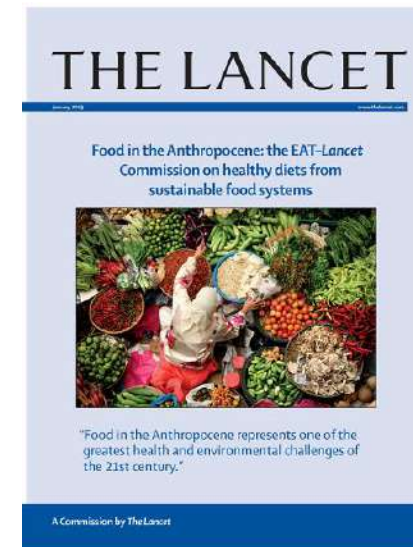








# Plant-based - Animal-optimized diets



# The destination can be beautiful, but the journey might be challenging without a roadmap





# We need realistic goals with a clear roadmap





# We need realistic goals with a clear roadmap

