

ライフサイクルアセスメント  
生命週期評估  
전 과정 평가  
வாழ்க்கை வட்டப் பகுப்பாய்வு

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ការវាយតម្លៃរង្វង់ជីវិត

Evaluarea Ciclului de Viață

Posuzování Životního Cyklu

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Levenscyclusanalyse

Livscyklusvurdering

# Life cycle assessment of novel plant products compared to animal products

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Life Cycle Assessments (LCA's) - The holy grail to foster change and convince consumers?

# Research questions

- How can one compare novel plant products with their animal-based counterparts?
- What is the environmental impact of different novel plant products?
- What difficulties and uncertainties exist in models of novel plant products?
- Are novel plant products a good alternative to animal-based products in terms of nutritional value?
- How many portions are needed to satisfy the nutritional intake?

## Why study novel plant products?

- Nutrition in general, and meat and animal-based products in particular, have been identified as a major driver of environmental impacts.
- Huge increase of processed plant products in the last years.
- So far little is known about their environmental impacts and function.





## Methodology and data

- Studied alternatives: Milk alternative, red meat alternatives, poultry alternatives, egg alternatives, fish alternatives and cream alternatives
- LCI includes: breeding, feeding, housing, agriculture, energy consumption (storing etc.), transport, food losses (until supermarket)
- LCIA method: European Footprint 3.0 and Global Warming Potential
- Background data: ESU world food database

[www.esu-services.ch/data/fooddata/](http://www.esu-services.ch/data/fooddata/)

## Functional unit

- How do you compare food items? Mass? Calories?
- Are novel plant products comparable to their animal-based counterparts?
- Unit: “Product per nutritional value (predominantly in animal-based products e.g. proteins, iron and more)“
- Does not include home transport, storage and preparation at home

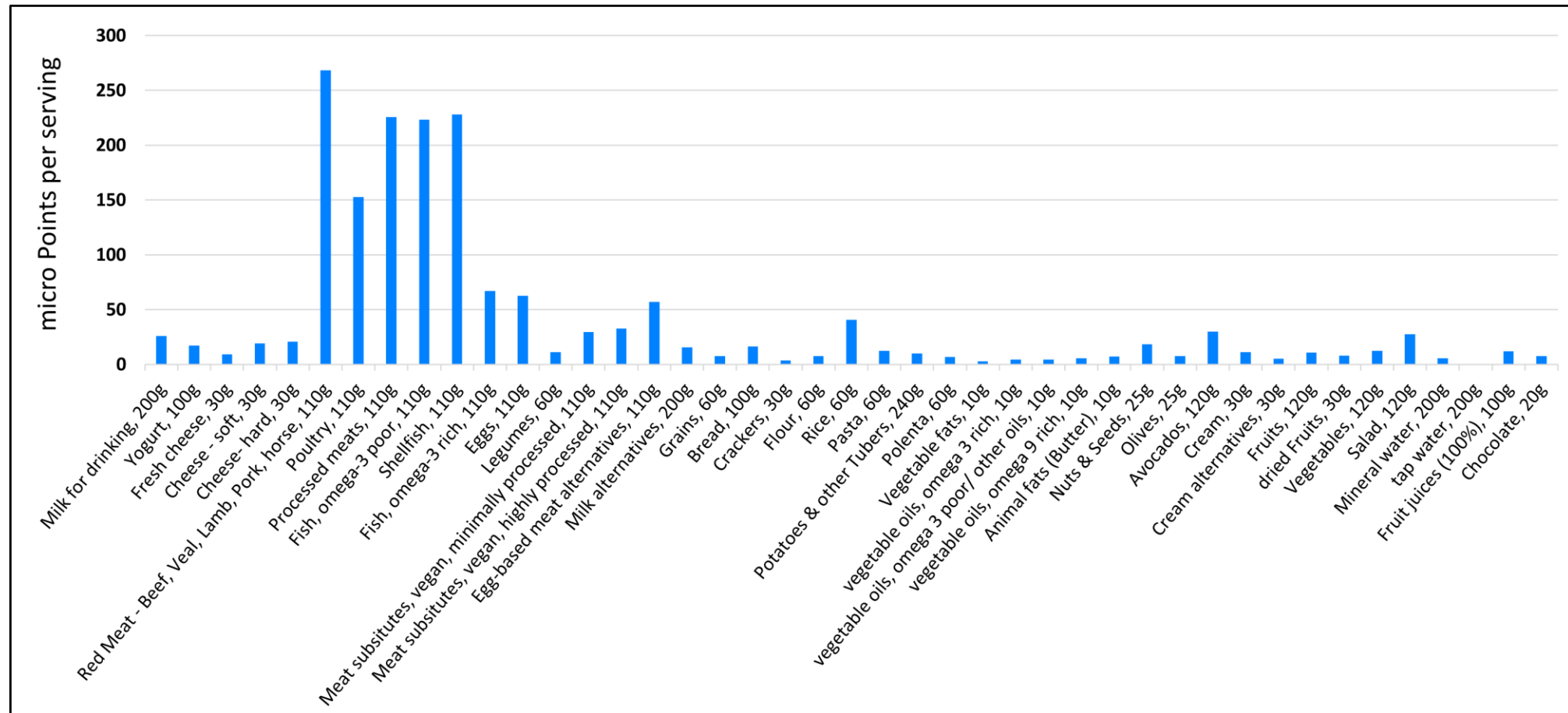
## Nutritional recommendations

Recommended daily nutritional intake per day according to Swiss society for nutrition:

- 64 g protein
- 4 µg vitamin B12
- 1.5 g omega-3 fatty acids
- 1 g of calcium
- 15 mg iron
- 150 µg iodine
- 14 mg zinc
- 1.4 mg riboflavin (vitamin B2)
- 15 µg vitamin D
- 70 µg selenium



# Environmental impacts per serving



➤ Animal based products have the highest impacts per serving

# Plant products compared to their animal-based counterparts (European footprint 3.0)

Reduction potential of environmental impact (EF 3.0)	64 g protein	4 µg vitamin B12	1.5 g omega-3 fatty acids	1 g of calcium	15 mg iron	150 µg iodine	14 mg zinc[4]	1.4 mg riboflavin (vitamin B2)	15 µg vitamin D	70 µg selenium
Drink instead of cow milk	22%	-21%	42%	-18%	na	-47%	21%		-93%	-96%
Instead of red meat ...										
Legumes	-94%	na	-83%	-99%	-98%	-91%	-92%	-88%	na	na
Meat substitutes, vegan, minimally processed	-92%	9983%	-86%	-99%	-92%	-93%	-66%	20%	na	-98%
Meat substitutes, vegan, highly processed	-86%	-13%	-95%	-98%	-91%	na	na	na	na	na
Egg-based meat alternatives	-68%	65%	-69%	-96%	-55%	na	-90%	na	na	na
Instead of poultry ...										
Legumes	-88%	na	-69%	-99%	-99%	-56%	-96%	-89%	na	na
Meat substitutes, vegan, minimally processed	-84%	1687%	-76%	-98%	-96%	-66%	-82%	9%	na	-90%
Meat substitutes, vegan, highly processed	-72%	-85%	-91%	-96%	-96%	na	na	na	na	na
Egg-based meat alternatives	-35%	-71%	-44%	-94%	-78%	na	-95%	na	na	na
Instead of eggs ...										
Legumes	-86%	na	-8%	-87%	-92%	495%	-90%	-55%	na	na
Meat substitutes, vegan, minimally processed	-82%	10176%	-28%	-74%	-75%	361%	-57%	360%	na	-78%
Meat substitutes, vegan, highly processed	-68%	-12%	-73%	-52%	-71%	na	na	na	na	na
Egg-based meat alternatives	-26%	68%	64%	-20%	50%	na	-87%	na	na	na
vegetable oil instead of fish										
omega 3 rich	na	na	-93%	3052%	na	na	895%	na	na	na
omega 3 poor/ other oils	3312%	na	-85%	544%	1161%	na	na	na	na	na
omega 9 rich	na	na	-95%	na	1620%	76301%	na	na	na	na
Vegan cream instead cream	-58%	na	-78%	228%	-99%	na	na	na	na	na

# Plant products compared to their animal-based counterparts (global warming potential)

Reduction potential of environmental impact (GWP)	64 g protein	4 µg vitamin B12	1.5 g omega-3 fatty acids	1 g of calcium	15 mg iron	150 µg iodine	14 mg zinc[4]	1.4 mg riboflavin (vitamin B2)	15 µg vitamin D	70 µg selenium
Drink instead of cow milk	37%	-11%	59%	-8%	na	-41%	35%	1268%	-92%	-96%
Instead of red meat ...										
Legumes	-95%	na	-85%	-99%	-98%	-92%	-93%	-90%	na	na
Meat substitutes, vegan, minimally processed	-91%	11733%	-84%	-99%	-91%	-92%	-61%	41%	na	-98%
Meat substitutes, vegan, highly processed	-81%	18%	-93%	-97%	-88%	na	na	na	na	na
Egg-based meat alternatives	-66%	73%	-68%	-96%	-53%	na	-90%	na	na	na
Instead of poultry ...										
Legumes	-84%	na	-60%	-99%	-98%	-43%	-94%	-86%	na	na
Meat substitutes, vegan, minimally processed	-73%	3001%	-58%	-97%	-93%	-41%	-68%	89%	na	-83%
Meat substitutes, vegan, highly processed	-43%	-69%	-82%	-93%	-91%	na	na	na	na	na
Egg-based meat alternatives	1%	-55%	-13%	-91%	-65%	na	-92%	na	na	na
Instead of eggs ...										
Legumes	-82%	na	18%	-84%	-90%	665%	-87%	-42%	na	na
Meat substitutes, vegan, minimally processed	-69%	17616%	24%	-54%	-56%	695%	-26%	692%	na	-63%
Meat substitutes, vegan, highly processed	-36%	77%	-46%	-5%	-42%	na	na	na	na	na
Egg-based meat alternatives	14%	159%	154%	23%	131%	na	-81%	na	na	na
vegetable oil instead of fish										
omega 3 rich	na	na	-94%	2706%	na	na	786%	na	na	na
omega 3 poor/ other oils	2779%	na	-88%	444%	965%	na	na	na	na	na
omega 9 rich	na	na	-96%	na	1104%	53402%	na	na	na	na
Vegan cream instead cream	-60%	na	-80%	209%	-99%	na	na	na	na	na

# How many portions are needed?

Number of servings	64 g protein	4 µg vitamin B12	1.5 g omega-3 fatty acids	1 g of calcium	15 mg iron	150 µg iodine	14 mg zinc[4]	1.4 mg riboflavin (vitamin B2)	15 µg vitamin D	70 µg selenium
Milk for drinking, 200g	10	9	1	4	na	8	18	3	150	30
Red Meat - Beef, Veal, Lamb, Pork, horse, 110g	3	1	0	96	6	56	3	4	8	8
Poultry, 110g	2	8	1	120	24	22	12	8	14	3
Fish, omega-3 poor, 110g	3	1	2	35	16	2	19	16	6	3
Shellfish, 110g	4	2	6	24	8	1	7	13	na	na
Fish, omega-3 rich, 110g	3	1	0	71	16	4	28	11	2	na
Eggs, 110g	5	3	0	19	8	3	11	4	8	3
Legumes, 60g	4	na	2	15	4	133	7	12	na	na
Meat substitutes, vegan, minimally processed, 110g	2	727	1	12	5	40	11	46	na	2
Meat substitutes, vegan, highly processed, 110g	3	6	0	20	5	na	na	na	na	na
Egg-based meat alternatives, 110g	4	6	1	19	14	na	2	na	na	na
Milk alternatives, 200g	20	11	2	6	38	7	35	70	18	2
vegetable oils, omega 3 rich, 10g	na	na	0	33333	na	na	4200	na	na	na
vegetable oils, omega 3 poor/ other oils, 10g	1600	na	1	6897	3000	na	na	na	na	na
vegetable oils, omega 9 rich, 10g	na	na	0	na	3000	30000	na	na	na	na
Cream, 30g	94	48	1	43	1000	39	187	30	121	na
Cream alternatives, 30g	85	na	0	303	25	na	na	na	na	na

➤ Number of necessary portions a problem for some nutrients

## Difficulties and uncertainties in the model

- Within the groups of food items there might be considerable differences concerning environmental impacts per portion and the nutrients per portion.
- Some plant-based alternatives contain enrichments for certain nutrients. So far it is difficult to analyze the environmental impact of such pure nutrients.
- Slight differences in the preparation of food in the kitchen are possible (e.g. shorter cooking time due to prebaking of the alternative)

## A first estimation to added nutrients

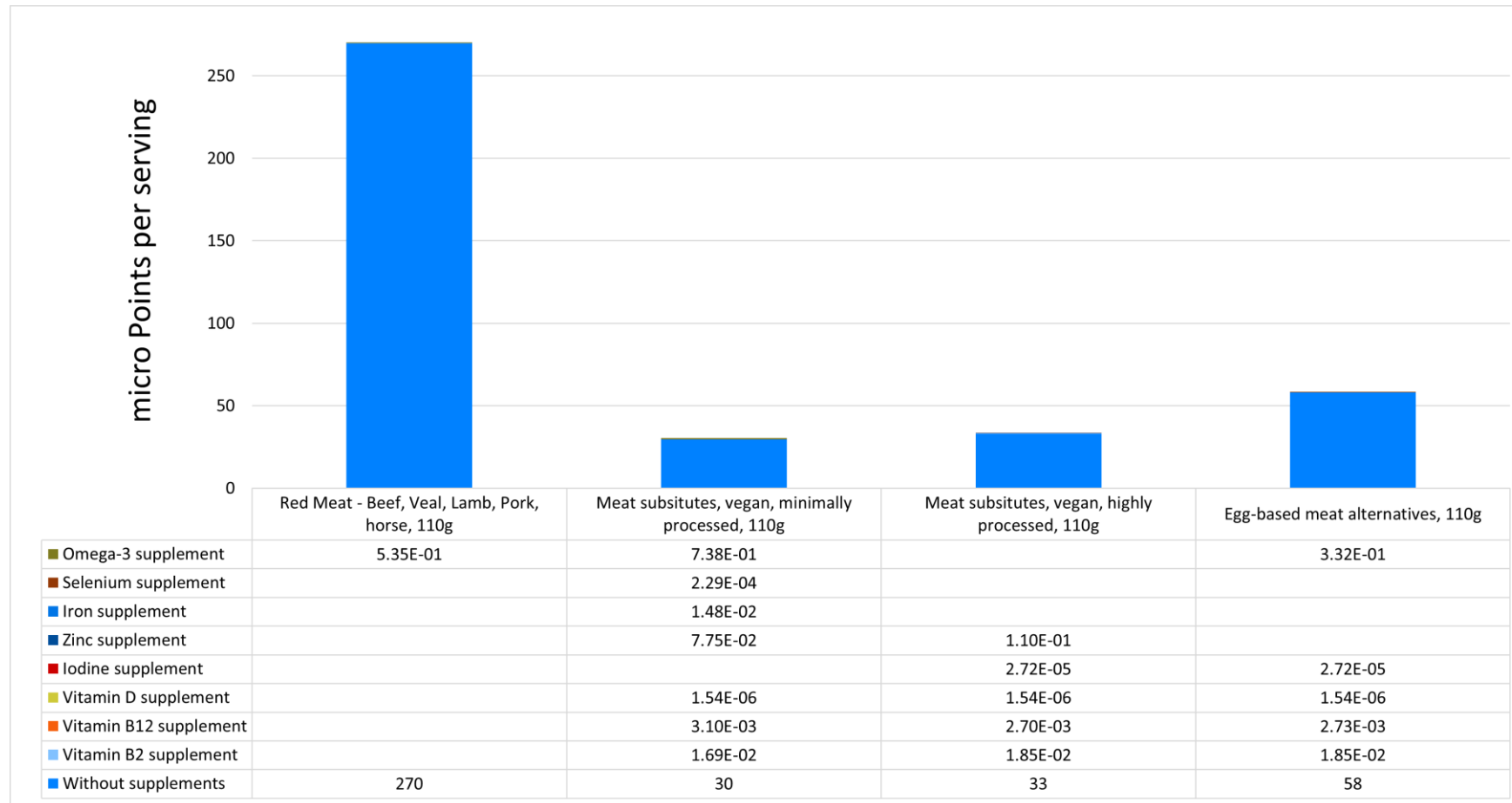
- A screening was performed to assess the environmental impact of added nutrients based on an input-output analysis with the bulk price
- The following nutrients were modelled: Vitamin A, B2, B12, D and E, as well as Calcium, Iodine, Zinc, Iron, Selenium, and Omega-3

	Daily recommended dose according to Swiss society for nutrition	Environmental impact of added nutrients if taken separately		
LCA Method		Ecological scarcity method 2021	EF 3.0	GWP
Unit		Pts	μPt	kg CO2-eq
Vitamin A	1 mg	9.84E-02	5.46E-03	3.42E-05
Vitamin B2	1.4 mg	1.40E+00	7.77E-02	4.87E-04
Vitamin B12	4 μg	4.39E-02	2.43E-03	1.53E-05
Vitamin D	15 μg	2.47E-04	1.37E-05	8.59E-08
Vitamin E	13 mg	3.79E+00	2.10E-01	1.32E-03
Calcium	1 g	3.01E+01	1.67E+00	1.05E-02
Iodine	150 μg	3.01E-02	1.67E-03	1.05E-05
Zinc	14 mg	7.18E+00	3.98E-01	2.50E-03
Iron	15 mg	3.21E+00	1.78E-01	1.12E-03
Selenium	70 μg	3.65E-02	2.03E-03	1.27E-05
Omega-3-fatty-acids	1.5 g	4.12E+01	1.05E+00	1.25E-02

➤ Low impacts compared to daily recommended dose



# Added nutrients to animal substitutes



- Protein content of substitutes is normally sufficient without additives
- Screening shows no environmental relevance for other additives

## Interpretation

- Protein and iron can be replaced very efficiently with several plant-based products and reductions of up to 90% for the environmental impacts
- It is difficult to replace vitamin B12 and seems only possible with plant-based alternatives with added vitamin B12.
- For calcium there are also good alternatives
- An obstacle can be the necessary servings per day to meet the necessary nutritional intake
- Nutrient supplements might overcome this obstacle if necessary

➤ A much more plant-based diet is possible without malnutrition

# Conclusion

- Plant based substitutes are an effective alternative to the consumption of meat
- Environmental impacts are an important cause of health impacts and premature deaths. Reducing the environmental impact of food consumption is necessary also for avoiding health impacts
- Further improvements can be expected by substituting more animal-based products with plant-based products.

➤ Download the study on [www.esu-services.ch/publications/foodcase/](http://www.esu-services.ch/publications/foodcase/)

➤ Niels Jungbluth, Martin Ulrich, Karen Muir, Christoph Meili, Maresa Bussa, Samuel Solin (2022) Analysis of food and environmental impacts as a scientific basis for Swiss dietary recommendations. ESU-services GmbH, Schaffhausen, Switzerland.

## Policy implications

- The present policies of retailers to promote vegan or vegetarian products mainly/exclusively for the group of consumers with high environmental awareness and willingness to pay is questionable.
- Products should be made available for fair prices.
- Direct and indirect subsidies on animal-based products should be reduced.

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