

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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Evaluarea Ciclului de Viață
Posuzování Životního Cyklu
Penilaian Daur Hidup
Lífsferilsgreining
Levenscyclusanalyse
Livscyklusvurdering

Life cycle assessment of novel plant
products compared to animal products

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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 within nutrition meat and animal-based products 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: Ecological Scarcity 2021, European Footprint 3.0 and Global Warming Potential
- Background data: ESU world food database
www.esu-services.ch/data/fooddata/

Functional Unit

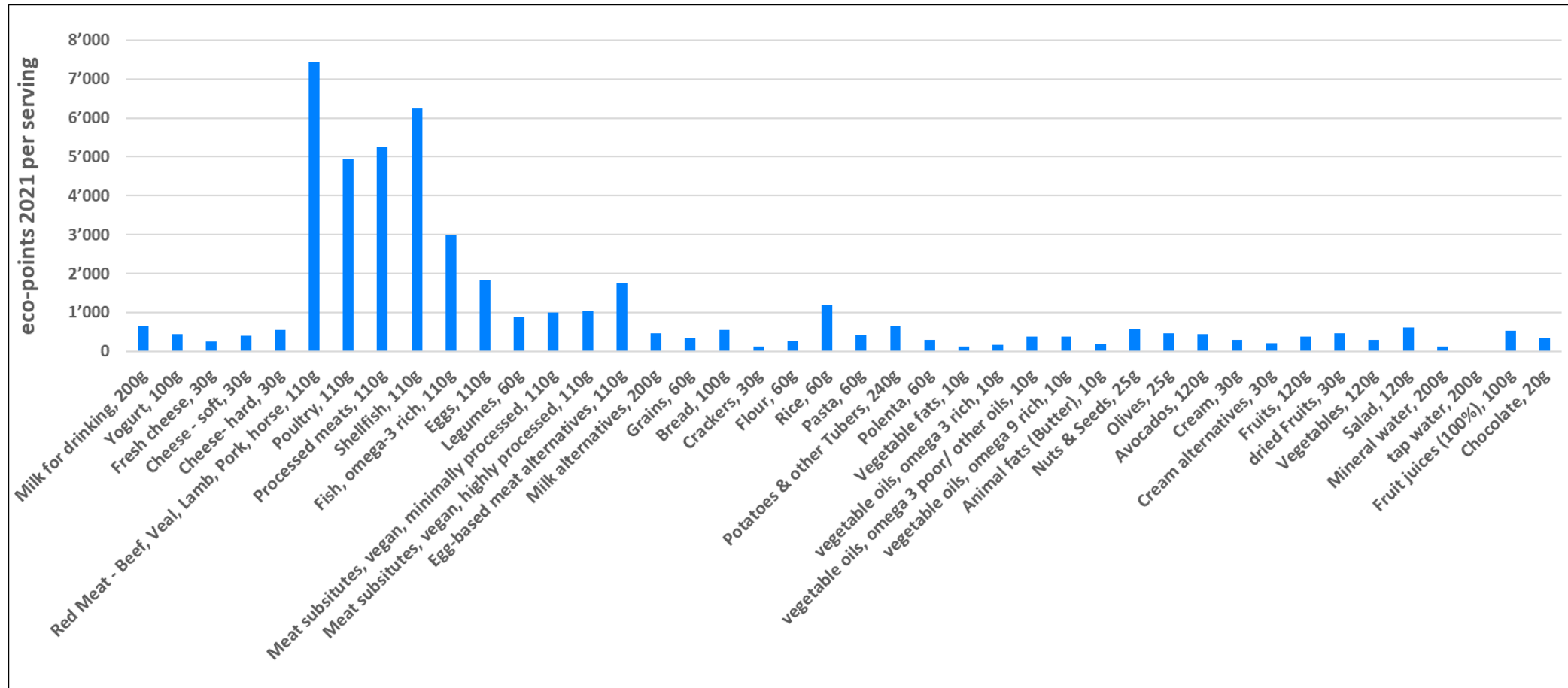
- How do you compare food items? Mass? Calories?
- Are novel plant products comparable to their animal-based counterparts?
- Unit: “Product per nutritional value (predominantly in animal-based products e.g. proteins, iron and more)”
- Does not include home transport, storage and preparation at home

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
- 1.4 mg riboflavin (vitamin B2)
- 15 µg vitamin
- 70 µg selenium

Environmental impacts per serving



- Animal based products have the highest impacts per serving

Plant products compared to their animal-based counterparts (ecological scarcity method 2021)

Reduction potential of environmental impact (ES 2021)	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	48%	-4%	73%	0%	na	-36%	46%		-91%	-96%
Instead of red meat ...										
Legumes	-83%	na	-52%	-98%	-96%	938%	-19%	52%	na	na
Meat substitutes, vegan, minimally processed	-90%	12330%	-83%	-98%	-91%	-91%	-59%	48%	na	-98%
Meat substitutes, vegan, highly processed	-84%	-1%	-94%	-97%	-90%	na	na	na	na	na
Egg-based meat alternatives	-65%	81%	-66%	-96%	-51%	na	-89%	na	na	na
Instead of poultry ...										
Legumes	-70%	na	-25%	-98%	-97%	6%	-89%	-74%	na	na
Meat substitutes, vegan, minimally processed	-83%	1781%	-74%	-98%	-96%	-64%	-81%	15%	na	-90%
Meat substitutes, vegan, highly processed	-72%	-85%	-91%	-97%	-96%	na	na	na	na	na
Egg-based meat alternatives	-39%	-73%	-48%	-94%	-79%	na	-95%	na	na	na
Instead of eggs ...										
Legumes	-62%	na	149%	-65%	-78%	1521%	-71%	24%	na	na
Meat substitutes, vegan, minimally processed	-79%	12128%	-14%	-69%	-70%	449%	-49%	447%	na	-74%
Meat substitutes, vegan, highly processed	-65%	-3%	-71%	-48%	-68%	na	na	na	na	na
Egg-based meat alternatives	-22%	78%	74%	-15%	59%	na	-87%	na	na	na
vegetable oil instead of fish										
omega 3 rich	na	na	-94%	2715%	na	na	788%	na	na	na
omega 3 poor/ other oils	13146%	na	-89%	4295%	4149%	na	na	na	na	na
omega 9 rich	na	na	-100%	na	2175%	164309%	na	na	na	na
Vegan cream instead cream	-34%	na	-66%	412%	-98%	na	na	na	na	na

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	10%	-29%	28%	-26%	na	-53%	9%		-94%	-97%
Instead of red meat ...										
Legumes	-97%	na	-91%	-100%	-99%	-95%	-96%	-94%	na	na
Meat substitutes, vegan, minimally processed	-86%	17415%	-77%	-98%	-87%	-88%	-42%	108%	na	-97%
Meat substitutes, vegan, highly processed	-76%	47%	-92%	-96%	-85%	na	na	na	na	na
Egg-based meat alternatives	-65%	80%	-66%	-96%	-51%	na	-89%	na	na	na
Instead of poultry ...										
Legumes	-96%	na	-90%	-100%	-100%	-85%	-98%	-96%	na	na
Meat substitutes, vegan, minimally processed	-83%	1832%	-74%	-98%	-96%	-63%	-80%	18%	na	-90%
Meat substitutes, vegan, highly processed	-70%	-84%	-90%	-96%	-95%	na	na	na	na	na
Egg-based meat alternatives	-56%	-80%	-62%	-96%	-85%	na	-96%	na	na	na
Instead of eggs ...										
Legumes	-91%	na	-41%	-92%	-95%	285%	-93%	-71%	na	na
Meat substitutes, vegan, minimally processed	-63%	21185%	50%	-45%	-48%	855%	-11%	852%	na	-55%
Meat substitutes, vegan, highly processed	-35%	78%	-46%	-4%	-42%	na	na	na	na	na
Egg-based meat alternatives	-4%	119%	115%	4%	96%	na	-84%	na	na	na
vegetable oil instead of fish										
omega 3 rich	na	na	-98%	632%	na	na	131%	na	na	na
omega 3 poor/ other oils	2606%	na	-88%	411%	901%	na	na	na	na	na
omega 9 rich	na	na	-97%	na	931%	45704%	na	na	na	na
Vegan cream instead cream	-44%	na	-71%	334%	-98%	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	42%	-8%	65%	-5%	na	-39%	40%	1315%	-92%	-96%
Instead of red meat ...										
Legumes	-96%	na	-88%	-100%	-98%	-93%	-94%	-91%	na	na
Meat substitutes, vegan, minimally processed	-91%	11520%	-84%	-99%	-91%	-92%	-61%	38%	na	-98%
Meat substitutes, vegan, highly processed	-81%	19%	-93%	-97%	-88%	na	na	na	na	na
Egg-based meat alternatives	-65%	77%	-67%	-96%	-52%	na	-89%	na	na	na
Instead of poultry ...										
Legumes	-89%	na	-74%	-99%	-99%	-62%	-96%	-91%	na	na
Meat substitutes, vegan, minimally processed	-79%	2338%	-67%	-97%	-95%	-53%	-75%	49%	na	-87%
Meat substitutes, vegan, highly processed	-54%	-75%	-85%	-94%	-93%	na	na	na	na	na
Egg-based meat alternatives	-18%	-63%	-29%	-92%	-72%	na	-93%	na	na	na
Instead of eggs ...										
Legumes	-85%	na	-2%	-86%	-91%	540%	-89%	-51%	na	na
Meat substitutes, vegan, minimally processed	-69%	17568%	24%	-55%	-56%	693%	-26%	690%	na	-63%
Meat substitutes, vegan, highly processed	-34%	80%	-46%	-3%	-41%	na	na	na	na	na
Egg-based meat alternatives	18%	168%	163%	28%	140%	na	-80%	na	na	na
vegetable oil instead of fish										
omega 3 rich	na	na	-96%	1980%	na	na	556%	na	na	na
omega 3 poor/ other oils	2826%	na	-87%	452%	982%	na	na	na	na	na
omega 9 rich	na	na	-97%	na	1091%	52787%	na	na	na	na
Vegan cream instead cream	-59%	na	-79%	220%	-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

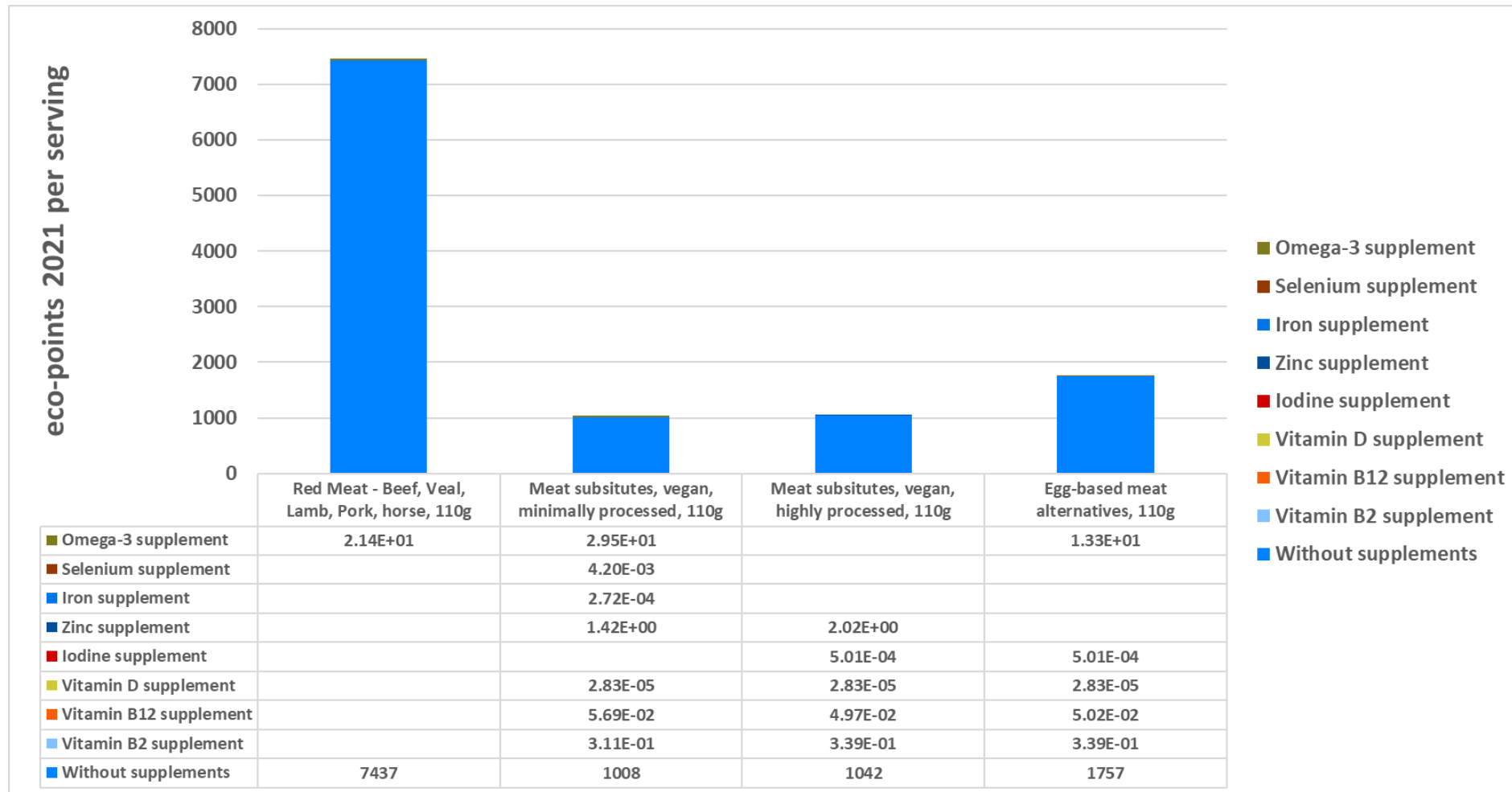
- Within the groups of food items there might be considerable differences concerning environmental impacts per portion and the nutrients per portion.
- Some plant-based alternatives contain enrichments for certain nutrients. So far it is difficult to analyze the environmental impact of such pure nutrients.
- 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

LCA Method	Daily recommended dose according to Swiss society for nutrition	Environmental impact of added nutrients if taken separately		
		Ecological scarcity method 2021	EF 3.0	GWP
Unit		eco-points	μPt	kg CO2-eq
Vitamin A	1 mg	1.25E-01	6.95E-03	4.44E-05
Vitamin B2	1.4 mg	1.43E+00	7.92E-02	5.06E-04
Vitamin B12	4 μg	4.47E-02	2.48E-03	1.58E-05
Vitamin D	15 μg	2.51E-04	1.40E-05	8.91E-08
Vitamin E	13 mg	3.86E+00	2.14E-01	1.37E-03
Calcium	1 g	2.94E+02	1.63E+01	1.04E-01
Iodine	150 μg	3.06E-02	1.70E-03	1.09E-05
Zinc	14 mg	7.31E+00	4.06E-01	2.59E-03
Iron	15mg	3.26E-03	1.63E-01	1.16E-03
Selenium	70 μg	3.72E-02	1.86E-03	1.33E-05
Omega-3-fatty-acids	1.5 g	4.20E+01	1.06E+00	1.32E-02

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 even more animal-based products with plant-based products.

Political 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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