Developing a composite sustainability index: milk and milk analogues

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Declarations

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Key References

1. Beal, T. et al. (2022). Priority Micronutrient Density in Foods. Front. Nutr., 9.
2. Drewnowski, A. (2018). Measures and Metrics of Sustainable Diets with a Focus on Milk, Yogurt, and Dairy Products. Nutr. Rev., 76(1), 21–28.
3. Drewnowski, A., & Fulgoni III, V. L. (2020). New Nutrient Rich Food Nutrient Density Models That Include Nutrients and MyPlate Food Groups. Front. Nutr., 7.
4. McLaren, S., & Chaudhary, A. (2021). Integration of Environment and Nutrition in Life Cycle Assessment of Food Items: Opportunities and Challenges.
5. Mendoza-Velázquez, A., et al. (2023). The Nutrient Rich Food Price Index: A Nutrition-Relevant Adaptation of the Laspeyres Price Index to Track the Cost of Affordable Nutrient Density. Front. Nutr., 10.
6. Smith, N. W. (2021). Use of the DELTA Model to Understand the Food System and Global Nutrition. J. Nutr., 151(10), 3253.

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Introduction

In a world battling with climate change, resource scarcity, and malnutrition, the need for sustainable decision-making is essential. While global food supply appears adequate, issues like food waste and affordability hinder nutritional access. Stakeholders, producers and consumer alike are further increasingly aware of environmental impacts, particularly in the dairy industry. Milk alternatives also emerge, of which the sustainability and nutritional contribution is still poorly understood. These factors emphasises the importance of minimising footprints while ensuring economic viability, as well as holistic evaluation of the sustainability of milk and milk analogues. To address these challenges within local contexts, this study aims to create a sustainability index tailored to milk and milk analogues, within a specific country. This index, which can be adapted to any country, can inform stakeholders to assess footprints and make informed choices, based on economics, nutrition and the environment, aligning the industry with global sustainability goals.

NUTRITION

A similar approach to the nutrient rich food index (NRFi) was followed, with weighting factor according to e.g:

- **bioavailability of nutrients**
- **food matrix effects**
- **age and sex specific requirements roups**
- **demographic strata**
- **contribution to global nutrient supply**
- **associated diseases or protective effects**
- **protein quality as a sub-score.**

ENVIRONMENT

The same principles of a life-cycle analysis (LCA) are used, with practical adaptations according to what is already measured on farms and within production systems, eg:

- **blue water use,**
- **fertiliser use**
- **land use**
- **electricity/energy use**
- **recyclable materials & waste**
- **LCA results (if system boundaries are alike)**
- **management practices**

ECONOMICS

This is assessed with consumer and producer indicators, as well as self-report binomial and point related questions , eg:

- **product price**
- **poverty levels (incl % of the population per level)**
- **financial contribution to the country**
- **number of employees**
- **production efficiencies**
- **future potential**

Application

The three scores are expressed by means of shorthand notation. This avoids masking of a poor score for one indicator with a good score of another indicator, but rather gives a transparent view of the different indicators and their respective score. The notation "Ni(pq): EnS: EcS will be used (Ni = nutrient index; pcq= protein quality; EnS = Environmental Score, and EcS= Economic Score. A high Ni or NS, low EnS and low EcS is favourable

Example: Ni(pq): EnS : EcS = 175.414 (12.65) : 0.781 : 1.043

NUTRITION SCORE

MILK		Content	Bioavailability (coefficient)	Population Nutrient Req.	Supplement coefficient	Contribution coefficient	Nutrient content sufficiency
NUTRIENT	Unit	/ 100ml	Bc	PNR (/day)	Sc	Cc	Nis
ENERGY	kJ	275.000	1.000	10494.300	1.000	1.087	**2.845**
CARBOHYDRATES*	g	5.370	1.000	354.418	1.000	1.053	**1.595**
FIBER	g	0.000	1.000	28.511	1.136	1.000	**0.000**
PROTEIN*	g	3.470	0.279	106.085	1.426	1.212	**1.546**
FAT*	g	3.350	1.000	75.436	1.000	1.227	**5.448**
POTASSIUM (K)	mg	167.660	0.007	2799.638	1.000	1.121	**0.048**
IRON (Fe)	mg	0.025	0.002	12.736	1.059	1.022	**0.000**
SODIUM (Na)	mg	48.120	1.000	1381.292	1.000	1.300	**3.464**
MAGNESIUM (Mg)	mg	11.930	0.005	321.733	1.000	1.125	**0.019**
CALCIUM (Ca)	mg	119.280	0.005	1064.088	1.424	1.405	**0.101**
PHOSPHORUS (P)	mg	85.600	0.006	723.207	1.000	1.448	**0.107**
VIT A	mg	0.040	0.001	794.602	1.185	1.190	**0.000**
VIT B2 (Riboflavin)	mg	0.190	0.008	1.131	1.000	1.333	**0.174**
VIT B12	mg	0.230	0.007	2.195	1.000	1.247	**0.085**
Vit B9 (Folate)	mg	4.700	0.006	379.439	1.747	1.058	**0.015**
VIT E	mg	0.125	1.000	13.922	1.416	1.000	**1.220**
ZINC	mg	1.000	0.003	9.061	1.000	1.109	**0.034**
IODINE	mg	0.010	0.010	157.962	1.000	1.000	**0.000**
AMINO ACIDS							
1: Nutrient Sufficiency Scores							**87.613**
AMINO ACIDS	**Unit**	**AA %**					**DIAA**
DIAAS (regular) (d1)	**pf1**	**1.000**					**0.000**
DIAAS 2nd degree (d2)	**pf2**	**0.505**					**27.805**
DIAAS 3rd degree (d3)	**pf3**	**0.343**					**44.939**
1.1: Protein completeness & quality factor		**DIAA (summed)**				**(pcq)**	**12.646**
HEALTH FACTORS	**Coefficient**					**Content**	
ADDED SUGAR (only added)	g	0.000	(Subtract)				**0.000**
TRANS FAT (PLANT SOURCE)	g	0.000	(Subtract)				**0.000**
GLYCEMIC INDEX c	Glc	0.000	(Subtract)				**0.000**
EXCLUSION THRESHOLD	ETs	0.975	(Multiply)				**0.975**
HEALTHY DIET CONTRIBUTION	HDCc	1.855	(Multiply)				**1.855**
SAFETY FACTOR (+/-)	Saf	TBC					
NUTRIENT SCORE						**NS**	**175.414**

ENVIRONMENTAL SCORE

PARAMATER	unit		unit/ton	CO2eq or score	
Potential lost	ton/ton		0.056		**0.058**
Land use	ha/ton		0.017		
Recycled material per ha	ha/ton		0.100		
Net land use	**ha/ton**		-0.083		**-0.083**
Farm Productivity score			**unit/kg**		**-0.025**
Fertiliser (if type not known)	kg/year	127.000.00	2174.658		1232.376
Pesticides (if type not known)	kg/year	40.000.00	684.932		3493.151
Fuel (incl material transport)	L/year	173.000.00	2962.329		1782.729
Electricity	kWh/year	375,300.00	6428.370		3867.380
Blue water	L/year	10,950.00	187.500		64.500
Farm Input & footprint score					**0.192**
MANAGEMENT & ENVIRONMENTAL INDICATORS				**Score**	
Cropping type	Mono-cropping			0.060	
Livestock use	Pasture based (single crops; with or wit...			0.020	
Soil type	Silt			0.020	
Improvement in efficiency yearly	More than 10%			0.010	
Reduction of inputs yearly	More than 10%			0.010	
Management score					**0.320**
1) Farm environmental score					**0.489**
Total litres of final product at factory	L		6000		
By-product yield	L/year	390.00			
Of which repurposed	kg	50.00	0.187		
Fuel (excluding distribution)	L/L	2370.00	790.000	475.422	
Fuel (distribution)	L/L	600.00	200.000	120.360	
Electricity	kW/L	200.00	66.667	40.120	
Blue water	L/L	3000.00	1000.000	344.000	
Factory input & footprint score					**0.163**
MANAGEMENT & ENVIRONMENTAL INDICATORS				**Score**	
Formal sustainability assessment (F)	Yearly			0.020	
Sustainability training or education (F)	Yearly			0.020	
Improvement in efficiency yearly	1-2%			0.040	
Reduction of inputs yearly	None			0.050	
Management score					**0.130**
2) Factory environmental score					**0.293**
ENVIRONMENTAL SCORE			**ES**		**0.781**

ECONOMIC SCORE

PARAMATER	Unit/Factor		Score
CONSUMER COST			
COST	R/100ml	R6.50	
PBPL (population bound poverty line)	p/d	R12.38	0.525
Price for reference poverty level:		**DBPL**	**0.525**
Raw material producer			
Gross profit (whole farm)	R/year	R260,320,000.00	
Wages (whole farm)	R/year	R1,500,680.00	
Taxes (whole farm)	R/year	R2,307,008.00	
Subsidies (whole farm)	R/year	R100,000.00	
RM: GDP (agriculture) contribution		**R264,527,688.00**	**0.229**
Total expenses	R/year	R87,600,000.00	
Income gained from repurposing waste	R/year	R1,005,000.00	
Total production	kg/year	58,400,000.00	
Holistic cost of production	R/kg	R1.48	
Holistic income from production	R/kg	R4.80	
RM: Cost/income Ratio			**0.309**
Employees on farm	**Nr employees**	**68.00**	**0.008**
Production potential	ton/year	62,000,000.00	
Potential lost	**ton/ton**		**0.058**
Raw material producer economic score			**-0.08**
Final product producer			
Gross profit (whole factory)	R/year	R860,350,000.00	
Wages (whole factory)	R/year	R12,050,008.00	
Taxes (whole factory)	R/year	R31,307,008.00	
Subsidies (whole factory)	R/year		
Processor: GDP (agriculture) contribution		**R903,707,076.00**	**0.729**
Total expenses	R/year	R112,500,000.00	
Income gained from repurposing waste	R/year	R860,367.00	
Processor: Cost/income Ratio			**0.139**
Employees on factory	**Nr employees**	**600.00**	**0.071**
Production potential	ton/year	150,000,000.00	
Potential lost	**ton/ton**		**0.333**
Processing producer economic score			**0.00**
ECONOMIC SCORE		**ES**	**1.043**

For illustrative purposes only, this scenario is built on hypothetical data from literature and market reports, ot validated for reporting. Complete table not shown.

Why the index?

Reliable methods are needed to measure and compare the sustainability of dairy products, which are tailored to specific the specific industry and countries. It should be easy-to-use based on available data.

Who will use it?

Producers and policy makers can use this for their own business decisions or science-based policy making. Consumers can use the results for their own informed consumer choices.

What are the benefits?

It is based on scientific data which has already been sourced and will continuously be adapted, meaning the data input required by users is limited, yet it will still yield reliable results.

Conclusion

The composite Sustainability index for Environment, Economics and Nutrition (SiEEN), which has been adapted to for milk and milk analogues as DiEET (Dairy index for Environment, Economics and nuTrition), integrates environmental, economic, and nutritional aspects of current validated tools, offering a practical means to assess and compare key sustainability indicators within a specific country. It contains adaptable data levels, based on scientific literature, which ensures industry relevance while accounting for data gaps. However, it's essential for producers to take up the responsibility of measuring their sustainability indicators and conducting more comprehensive nutrient testing to enable accurate comparisons. Ongoing refinement and validation of this index will be necessary in the aim continue to provide a transparent, sensible, and actionablemeasurement approach.

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