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Supplementary table 1: South African nutrient requirements based on demographic strata [1,2]

Nutrient	Unit	PNR Total
Energy	kJ/d	10 494.30
Carbohydrates*	g/d	354.42
Fibre	g/d	28.51
Protein*	g/d	108.09
Fats*	g/d	75.44
PUFA*	g/d	15.31
MUFA*	g/d	26.44
Omega 3 (alpha l)	g/d	1.28
Omega 6 (lin)	g/d	12.99
Saturated fat*	g/d	24.77
Trans fat	g/d	2.76
Potassium (K)	mg/d	2799.84
Iron (Fe)	mg/d	12.73
Sodium (Na)	mg/d	1381.29
Magnesium (Mg)	mg/d	321.73
Calcium (Ca)	mg/d	1064.09
Phosphorus (P)	mg/d	723.21
Vitamin A	µg/d	794.60
Vitamin B2 (riboflavin)	mg/d	1.13
Vitamin B12	µg/d	2.20
Vitamin B9 (folate)	µg/d	379.46
Vitamin D	µg/d	15.63
Vitamin E	mg/d	13.92
Zinc	mg/d	9.06
Iodine	µg/d	157.96
Amino acids		
Histidine	mg/d	1659.90
Leucine	mg/d	6446.57
Lysine	mg/d	4972.00
Methionine (+cystine)	mg/d	2416.50
Threonine	mg/d	2557.22
Tryptophan	mg/d	735.83
Isoleucine	mg/d	3247.26
Phenylalanine (+tyrosine)	mg/d	4220.12
Valine	mg/d	4250.95

PNR, population nutrient requirement
Dietary Reference Intakes (DRIs) and FAO[1] Amino acids are adapted according to scoring patterns and protein requirement
**Macro requirements based on PURE Healthy[2]*
Energy based on moderate physical activity and average extra daily requirement for the whole pregnancy; M: male, F: female, P/L: pregnant and/or lactating

Supplementary table 2: Age and gender distribution of the South African population (including the nutrient brackets to which each category was applied)[3]

Age (daily recommended intake bracket)	Male	%	Female	%
0–4 (0–3, divided equally)	2 884 691	4.76%	2 809 831	4.64%
5–9 (4–8)	2 837 833	4.68%	2 766 037	4.56%
10–14 (9–13)	2 890 269	4.77%	2 824 108	4.66%
15–19 (14–18)	2 566 719	4.24%	2 534 956	4.18%
20–24 (19–30)	2 351 752	3.88%	2 327 273	3.84%
25–29 (19–30)	2 626 342	4.33%	2 577 765	4.25%
30–34 (30–50)	2 833 963	4.68%	2 761 813	4.56%
35–39 (30–50)	2 583 697	4.26%	2 546 286	4.20%
40–44 (30–50)	1 990 106	3.28%	2 043 181	3.37%
45–49 (30–50)	1 607 584	2.65%	1 699 172	2.80%
50–54 (50–70)	1 262 718	2.08%	1 419 523	2.34%
55–59 (50–70)	999 048	1.65%	1 261 065	2.08%
60–64 (50–70)	777 905	1.28%	1 068 241	1.76%
65–69 (50–70)	578 724	0.95%	858 302	1.42%
70+	833 531	2.81%	1 482 557	4.79%

Supplementary table 3: South African birth numbers and percentage of pregnancies per age group[3,4]

Birth rate	1.79%
Number of births	1 087 526
% of females	3.51%
Age groups	Percentage pregnancies per group
10–19 (14–18)	13.12%
20–30	47.00%
30+	39.88%

Supplementary table 4: Global nutrient supply of nutrients based on the 2020 baseline setting of the Delta model[5] in relation to population nutrient requirements

Nutrient	Unit	Supply*	Daily requirement	Supplement needed
Energy	kJ	11 208.98	10 494.30	-714.68
Carbohydrates	g	401.51	354.42	-47.10
Fibre	g	26.26	28.51	2.25
Protein	g	64.62	108.09	43.46
Fat	g	83.80	75.44	-8.36
Potassium (k)	mg	3239.47	2799.84	-439.63
Iron (Fe)	mg	12.66	12.73	0.07
Sodium (Na)	mg	424.32	321.73	-102.58
Magnesium (Mg)	mg	622.82	1064.09	441.27
Calcium (Ca)	mg	1383.25	723.21	-660.04
Phosphorus (P)	mg	645.68	794.60	148.92
Vit A	mg	1.61	1.13	-0.48
Vitamin B2 (riboflavin)	µg	3.93	2.20	-1.73
Vitamin B12	µg	385.02	1381.29	996.27
Vitamin B9 (folate)	µg	2.68	379.46	376.77
Vitamin E	µg	8.99	15.63	6.64
Zinc	mg	10.53	9.06	-1.47
Histidine	mg	1678.77	1659.90	-18.86
Leucine	mg	4886.96	6446.57	1559.61
Lysine	mg	3512.51	4972.00	1459.49
Threonine	mg	2343.99	2557.22	213.23
Tryptophan	mg	751.15	735.83	-15.32
Met + cysteine	mg	2348.22	2416.50	68.28
Methionine	mg	1364.83	2416.50	1 051.66

Supplementary table 5: Percentage of raw material in final product, based on market investigations in Gauteng

Product	Number of brands used	Average percentage raw material
Oat beverage	8	11.21%
Soy beverage	4	6.75%
Almond beverage	9	2.40%
Bovine milk	10	100.00%

Information was gathered from labelling or website information provided by the different anonymous brands in Gauteng. The percentage refers to ingredient bases (e.g. bovine milk had no added ingredients, thus only raw milk was processed into the final product, which makes bovine milk the only ingredient).

Supplementary table 6: Nutrient contribution ratios per food group (adjusted to content in final product)

Nutrient	Milk	Oats	Adjusted	Soybean	Adjusted	Nuts	Adjusted
Energy	0.0669	0.0027	0.0003	0.0041	0.0003	0.0058	0.0001
Carbohydrates	0.0378	0.0034	0.0004	0.0022	0.0001	0.0017	0.0001
Fibre	0.0000	0.0072	0.0008	0.0082	0.0006	0.0080	0.0002
Protein	0.1654	0.0041	0.0005	0.0116	0.0008	0.0066	0.0003
Fat	0.1288	0.0017	0.0002	0.0069	0.0005	0.0184	0.0002
Potassium (K)	0.1183	0.0021	0.0002	0.0120	0.0008	0.0050	0.0003
Iron (Fe)	0.0107	0.0060	0.0007	0.0224	0.0015	0.0082	0.0005
Magnesium (Mg)	0.1144	0.0089	0.0010	0.0174	0.0012	0.0155	0.0004
Calcium (Ca)	0.3192	0.0009	0.0001	0.0073	0.0005	0.0029	0.0002
Phosphorus (P)	0.4409	0.0151	0.0017	0.0254	0.0017	0.0193	0.0006
Vitamin A	0.1076	0.0000	0.0000	0.0002	0.0000	0.0002	0.0000
Vitamin B2 (riboflavin)	0.3335	0.0015	0.0002	0.0101	0.0007	0.0054	0.0002
Vitamin B12	0.2597	0.0000	0.0000	0.0000	0.0000	0.0000	0.0000
Vitamin B9 (folate)	0.0409	0.0029	0.0003	0.0303	0.0020	0.0039	0.0007
Vitamin E	0.0004	0.0000	0.0000	0.0009	0.0001	0.0160	0.0000
Zinc	0.0894	0.0061	0.0007	0.0090	0.0006	0.0081	0.0002
Cystine	0.1297	0.0087	0.0010	0.0186	0.0013	0.0099	0.0004
Histidine	0.3097	0.0074	0.0008	0.0245	0.0017	0.0114	0.0006
Leucine	0.2854	0.0058	0.0007	0.0191	0.0013	0.0085	0.0005
Lysine	0.2999	0.0039	0.0004	0.0203	0.0014	0.0058	0.0005
Methionine	0.3658	0.0076	0.0008	0.0149	0.0010	0.0100	0.0004
Threonine	0.3257	0.0057	0.0006	0.0264	0.0018	0.0098	0.0006
Tryptophan	0.3848	0.0097	0.0011	0.0313	0.0021	0.0137	0.0008

Sources: Delta Model[5] based on standard settings for 2020, baseline scenario
Note: average raw material content is used; however, if a single product is measured with a known raw material percentage, this can be replaced.

Supplementary table 7: Amino acid scoring pattern, adapted to yield a population scoring pattern[1,6,7]

Amino acid	IDc	Infants	1–2 y	3–10 y	11–14 y	15–18 y	>18 y	Population scoring pattern
His	0.900	20.0	18.0	16.0	16.0	16.0	15.0	16.21
Ile	0.910	32.0	31.0	30.0	30.0	30.0	30.0	31.27
Leu	0.920	66.0	63.0	61.0	61.0	61.0	59.0	62.29
Lys	0.940	57.0	52.0	48.0	48.0	48.0	45.0	48.41
Met + Cys	0.860	27.0	25.0	23.0	23.0	23.0	22.0	23.48
Phe + Tyr	0.890	52.0	46.0	41.0	41.0	41.0	38.0	41.28
Thr	0.850	31.0	27.0	25.0	25.0	25.0	23.0	24.97
Trp	0.770	8.5	7.0	6.6	6.6	6.6	6.0	6.55
Val	0.900	43.0	41.0	40.0	40.0	40.0	39.0	41.03

IDc, Ileal digestibility coefficient
Note: nearest age group percentiles used.;

Supplementary table 8: Global allergy and disease incidences specific to milk and plant-based beverages[8-12]

Allergy or disease	Product	Prevalence (fraction)
Milk allergy	Milk	0.005
Maltase-glucoamylase deficiency	Oats	0.020
Sucrase-isomaltase deficiency	Soybean	0.001
Almond nut allergy	Almonds	0.010
Soybean allergy	Soybean	0.017
Lactose intolerance*	Milk	0.810

**Lactose intolerance refers to the digestive issues experienced after consumption of lactose and not to lactase impersistence which describes the natural decline in lactase production after infancy*

Supplementary table 9: Environmental footprint of almond cultivation[13]

Indicator	Unit	Value	Comment
Fuel	kg/ha	20 365.91	Diesel + gasoline
Propane gas	kg/ha	98.9871	
Electricity	kWh/ha	83 156.86	
Pesticide	kg/ha	4 167.77	Nursery + orchard
Fertiliser N	kg/ha	3614.00	Nursery + orchard
Fertiliser P	kg/ha	4142.56	Nursery + orchard
Fertiliser K	kg/ha	224.6913	Nursery + orchard
Total synthetic fertiliser	kg/ha	21 075.32	Nursery + orchard
Blue water (irrigation)	kL/ha	2 986 840	
Yield	t/ha	2.33	Lifetime average per year
Maximum yield	t/ha	2.742	Based on maximum achieved in the area per year (lifetime average per year)
Average age at removal	years	21.533	
Additional material input	kg/ha	1147.81	Planting + irrigation
Density	trees/ha	312.4028	(Sapling required: 170.81 kg/ha)
Co-product generated	kg/ha	3401.71	Biomass, tree loss, hulls etc. (lifetime total averaged per year)
Recycled into farm	kg/ha	1295.741	Soil mulch, etc. (lifetime total averaged per year)
Sold/repurposed	kg/ha	1709.11	Dairy feed, energy generation (lifetime averaged per year)
In-field burning	kg/ha	396.8569	(Lifetime total averaged per year)

Supplementary table 10: Environmental footprint of oats cultivation[14,15]

Indicator	Unit	Value	Comment
Fuel	kg/ha	50.3	Transport to silo 3.6 L, 5.5 L
Electricity	kWh/ha		Only farm maintenance (security, housing) – not recorded
Fertiliser N	kg/ha	77.75	
Fertiliser P	kg/ha	18.85	
Fertiliser K	kg/ha	6.25	
Lime	kg/ha	425	
Fungicide	kg/ha	0.4	
Insecticide	kg/ha	0.41	
Herbicide	kg/ha	1	
Blue water (irrigation)	kL/ha	0	Winter wheat planted in winter rainfall area
Yield	t/ha	2.95	
Maximum yield	t/ha	3.3	
Co-product generated	t/ha	2625.5	Crop residues
Recycled into farm	t/ha	172.42	29.8% residues left – 1% burnt
Sold/repurposed	t/ha	1844.525	70.2% residues removed
In-field burning	t/ha	7.81	1% burnt

Based on wheat grown in South Africa

Supplementary table 11: Environmental footprint of soybean cultivation[16-19]

Indicator	Unit	Value	Comment
Fuel	kL/ha	189.2	
Electricity	kWh/ha	2091.68	Drying beans = 133.88
Fertiliser N	kg/ha	60	
Fertiliser P	kg/ha	7	
Fertiliser K	kg/ha	19	
Lime	kg/ha	5.7	Both before and after harvest
Pesticide	CO_2eq/ha	628.6	Input not provided, only carbon eq.
Blue water (irrigation)	kL/ha		Not under irrigation
Yield	t/ha	1.8	
Maximum yield	t/ha	2.38	
Co-product generated	t/ha	2.94	Crop residues
Recycled into farm	t/ha	1.0584	36% residues remaining
Sold/repurposed	t/ha	1.65	56% residues collected or repurposed
In-field burning	t/ha	0.235	8% burnt

Supplementary table 12: Environmental footprint of dairy production[20,21]

Indicator	Unit	Value
Farm size	ha	310
Herd	nr	1188
Of which dairy	nr	588
Milk production	l/year	5 730 000
Per cow per year	l/year	9 744.897959
Feed produced	ton/year	12 960
Feed purchased	ton/year	3360
N fertiliser	kg/ha	68
P fertiliser	kg/ha	0
Electricity	kwH/year	335 000
Fuel use	L/year	128 600
Milk production	l/year	6 546 500
Water	l/l	0.046
Electricity	kwH/L	0.056

Supplementary table 13: Nutrient score outline

Nutrient score						
Milk (milk type selected by user)		Content	Population nutrient requirement	Supplement coefficient	Contribution coefficient	Nutrient content sufficiency
Nutrient	**Unit**	**100 mL**	**PNR (/day)**	**Sc**	**Cc**	**NSs**
Energy	kJ		10 494.300	1.000	1.067	
Carbohydrates*	g		354.418	1.000	1.038	
Fibre	g		28.511	1.079	1.000	
Protein*	g		108.085	1.402	1.165	
Fat (count if type unknown)	g		75.436	1.000	1.129	
PUFA*	g		15.310	1.000	1.000	
MUFA*	g		26.445	1.000	1.000	
Omega 3 (alpha l)	g		1.285	1.000	1.000	
Omega 6 (lin)	g		12.991	1.000	1.000	
Saturated fat*	g		24.774	1.000	1.000	
Trans fat	g		1.682	1.000	1.000	
Potassium (K)	mg		2 799.838	1.000	1.118	
Iron (Fe)	mg		12.735	1.330	1.011	
Magnesium (Mg)	mg		321.733	1.000	1.114	
Calcium (Ca)	mg		1 064.088	1.415	1.319	
Phosphorus (P)	mg		723.207	1.000	1.441	
Vitamin A	mg		794.602	1.330	1.108	
Vitamin B2 (riboflavin)	mg		1.131	1.000	1.333	
Vitamin B12	mg		2.195	1.000	1.260	
Vitamin B9 (folate)	mg		379.459	1.721	1.041	
Vitamin D	mg		15.633	1.993	1.000	
Vitamin E	mg		13.922	1.425	1.000	
Zinc	mg		9.061	1.330	1.089	
Iodine	mg		157.962	1.000	1.000	
Amino acids						
Histidine	mg		1 659.902	0.989	1.310	
Leucine	mg		6 446.566	1.242	1.285	
Lysine	mg		4 972.003	1.294	1.300	
Methionine (+cystine)	mg		2 416.498	1.028	2.495	
Threonine	mg		2 557.216	1.083	1.326	
Tryptophan	mg		735.833	0.979	1.385	
Isoleucine	mg		3 247.257	1.000	1.000	
Phenylalanine (+tyr)	mg		4 220.116	1.000	1.000	
Valine	mg		4 250.946	1.000	1.000	

1: Nutrient sufficiency score total					
Amino acids	Unit	AA %			IAA
Histidine	mg/g				
Leucine	mg/g				
Lysine	mg/g				
Methionine (+cystine)	mg/g				
Threonine	mg/g				
Tryptophan	mg/g				
Isoleucine	mg/g				
Phenylalanine (+tyr)	mg/g				
Valine	mg/g				
1.1: Protein completeness factor		IAA (summed)		(pc)	
Health factors	Coefficient		PNR (/day)		Sub-factors
Added sugar (only added)	g				
Natural sugar	g				
Sodium (Na)	mg		1 381.292		
Exclusion threshold	Etc				
Healthy diet contribution	HDCc				
Nutrient score				NS	

Key

User input
Variable based on milk type
Automatic calculated value
Automatic calculated score

Supplementary table 14: Environmental score outline

Parameter	Unit	Usage	Unit/ton
Total land	ha		
Yield	kL/ha		
By-product yield	Ton/ha		
Of which recycled into farm	Ton/ha		
Of which yielding a product or electricity	Ton/ha		
Production potential	Ton/ha		
Potential lost	Ton/ha		
Land use	ha/ton		
Net yield (yield-by-product) per ha	Ton/ha		
Net land use	ha/ton		
Farm productivity score			
Total synthetic fertiliser	Ton/ha		
N fertiliser	Ton/ha		
P fertiliser	Ton/ha		
K fertiliser	Ton/ha		
Lime	Ton/ha		
Pesticides (if type not known)	Ton/ha		
Herbicides	Ton/ha		
Insecticides	Ton/ha		
Fungicides	Ton/ha		
Fuel (including material transport)	kL/ha		
Electricity	kWh/ha		
Blue water	kL/ha		
Farm input and footprint score			
Management and environmental indicators (see Supplementary table 15 for input options)			
Cropping type			
Livestock use			
Soil type			
Soil test frequency			
Water test frequency			
Formal sustainability assessment (f)			
Crop health and/or livestock welfare assessment (f)			
Environmental score outline continued			
Sustainability training or education (f)			
Improvement in efficiency yearly			
Reduction of inputs yearly			

Management score			
1) Farm environmental score			
Total litres produced at factory	kL		
Of which product in question	kL		
By-product yield	L/L		
Of which recycled into processing	L		
Of which a product or electricity	L		
Fuel (excluding distribution)	L/L		
Fuel (distribution)	L/L		
Electricity	Wh/L		
Blue water	L/L		
Are product specific inputs accurately measured in the factory?			
Total litres of final product at factory	L/year		
By-product yield	kg/year		
Of which repurposed	kg/year		
Of which a product or electricity	kg/year		
Packaging used	kg/year		
Fuel (excluding distribution)	L/year		
Fuel (distribution)	L/year		
Electricity	kW/L/year		
Blue water	L/year		
Factory input and footprint score			
Management and environmental indicators (see Supplementary table 15 for input options)			
Formal sustainability assessment (f)			
Sustainability training or education (f)			
Improvement in efficiency yearly			
Reduction of inputs yearly			
Management score			
2) Factory environmental management score			
Environmental score		EnS	

Key: *green=user input; orange=calculated value; blue=subscore calculated value*

Supplementary table 15: Qualitative indicators question and user input options

Question/qualitative indicator	Options
Cropping type	Mono-cropping Rotational-cropping Inter-cropping Cover-cropping Regenerative cropping Agroforestry
Livestock use	None (if crops only without integration of livestock) TMR (no fodder carry) Post-harvest grazing (not for milking) TMR with Fodder carry Pasture based (single crops; with or without supplements)) Pasture based (mixed veld, with or without supplements)
Soil type	Sandy Clay Loam Silt Peat
Soil test frequency Water test frequency Formal sustainability assessment (f) Crop health and/or livestock welfare assessment (f) Sustainability training or education (f)	Never 5-10 years 2-5 years Yearly Twice or more per year
Improvement in efficiency yearly Reduction of inputs yearly	None 1-2% 2-5% 5-10% More than 10%

Supplementary table 16: Economic score outline

Parameter	Unit/factor	
Consumer cost		
Affordability		
COST	ZAR/100 mL	
FPL	pf1	
LBLP	pf2	
UBPL	pf3	
DBPL	pf4	
Price for reference poverty level:	**Poverty level**	
Producer economic indicators		
Raw material producer		
Gross profit (whole farm)	ZAR/year	
Wages (whole farm)	ZAR/year	
Taxes (whole farm)	ZAR/year	
Subsidies (whole farm)	ZAR/year	
RM: GDP (agriculture) contribution		
Total expenses	ZAR/year	
Income gained from repurposing waste	ZAR/year	
Total production	kg/year	
Holistic cost of production	ZAR/kg	
Holistic income from production	ZAR/kg	
RM: Cost/income ratio		
Employees on farm	No. employees	
Production potential	ton/year	
Potential lost	ton/ton	
Raw material producer economic score		
Final product producer		
Gross profit (whole factory)	ZAR/year	
Wages (whole factory)	ZAR/year	
Taxes (whole factory)	ZAR/year	
Subsidies (whole factory)	ZAR/year	
Processor: GDP (agriculture) contribution		
Economic score outline continued		
Total expenses	ZAR/year	
Income gained from repurposing waste	ZAR/year	
Total production	kg/year	
Holistic cost of production	ZAR/kg	
Holistic income from production	ZAR/kg	

Processor: Cost/income ratio		
Employees on factory	No. employees	
Production potential	ton/year	
Potential lost	ton/ton	
Processing producer economic score		
Economic score	**EcS**	

Key: *green=user input; orange=calculated value; blue=subscore*

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