

Table S1. Nutrient constraints applied during all linear optimization procedures.

Reference pupil – nutritional constraints for optimized food supply

	Lower limit	Upper limit
Energy (kcal)^a	604	604
Carbohydrates (%E)^b	45	60
Fat (%E)^b	22	40
Protein (%E)^b	10	20
Fiber (%E)^c	2	—
Saturated fatty acids (%E)^b	—	10
Mono unsaturated fatty acids (%E)^b	10	20
Poly unsaturated fatty acids (%E)^b	5	10
Vitamin A (µg)^c	168	—
Vitamin D (µg)^c	3	30
Vitamin E (mg)^c	2.2	90
Thiamine (mg)^c	0.3	—
Riboflavin (mg)^c	0.4	—
Vitamin C (mg)^c	15.3	300
Niacin (mg)^c	4.2	270
Vitamin B6 (mg)^c	0.4	7.5
Vitamin B12 (µg)^c	0.5	—
Folate (µg)^c	57.6	300
Phosphor (mg)^c	190.8	900
Iodine (µg)^c	41.4	180
Iron (mg)^c	3.3	7.5
Calcium (mg)^c	246	750
Potassium (mg)^c	810	—
Magnesium (mg)^c	76.5	—
Salt (g)^d	—	3.6
Selenium (µg)^c	11.7	90
Zink (mg)^c	2.7	7.5
Omega-3 fatty acids (%E)^c	3.3	—

^aBased on 30% of daily estimated energy requirement (EER), averaged values over 10 grades (preparatory class to ninth grade) and both sexes.

^bLower and upper limits based on 30% of daily recommended intake ranges, averaged values over 10 grades (preparatory class to ninth grade) and both sexes.

^cLower limit based on 30% of daily recommended intakes (RIs) and upper limit based on 30% of daily Upper intake levels (ULs), averaged values over 10 grades (preparatory class to ninth grade) and both sexes.

^dUpper limit based on 30% of daily recommended intake (RIs).

Table S2. Amounts, cost, RDs, and associated GHGE (CO₂eq) of individual food items in observed and optimized supply, respectively, when minimizing GHGE and applying constraints on nutritional adequacy only (Model 1, GHGE_{min}).

Food	School 1 (SEK 6.50 ^a)				School 2 (SEK 5.54 ^a)				School 3 (SEK 3.88 ^a)			
	Amount ^b (g)		Change ^c (RD, %)	CO ₂ eq ^d (g)	Amount ^b (g)		Change ^c (RD, %)	CO ₂ eq ^d (g)	Amount ^b		Change ^c (RD, %)	CO ₂ eq ^d (g)
	Observed	Optimized			Observed	Optimized			Observed	Optimized		
Crisp bread	0.03	59.39	209156%	17.8								
Wheat bran									0.24	4.5	1777%	0.9
Semolina					0.86	55.24	6323%	24.3	0.55	17.95	3193%	7.9
Potato	22.90	133.43	483%	13.3	5.52	212.57	3748%	21.3				
Lentils dried									0.44	3.92	788%	1.3
Chickpeas dried	0.13	53.19	40338%	19.7	0.06	56.54	87254%	20.92				
Olive oil									0.15	3.61	2284%	7.4
Margarine 80%	0.53	2.35	341%	3.7	0.52	0.54	4%	0.85				
Parsley	0.05	42.27	91729%	14.8								
Carrots					1.29	11.89	818%	1.31	11.36	14.94	32%	1.6
Lingonberries									0.38	6.63	1652%	5.7
Anchovies									0.06	48.62	80149%	14.1
Pickled herring	0.063	20.65	32602%	12.8	0.08	5.2	6249%	3.2	0.04	0.94	49943%	11.7
Breaded herring	0.036	6.61	18511%	4.1								
Salt					0.52	0.06	-88%	0.02	0.04	0.22	480%	0.1
Total				86 (10.6%)^e				72 (7.0%)^e				51 (5.3%)^e

^aCost of food supply per reference portion after optimization.

^bAbsolute raw amount of individual food items in observed and optimized supply, respectively.

^cRelative change from observed food supply during the school year 2015/2016 after optimization.

^dAmount of carbon dioxide equivalents (CO₂eq) of food supply after optimization.

^ePercentage of observed GHGE

GHGE, Greenhouse gas emissions.

GHGE_{min}, optimized for lowest achievable GHGE.

		GHGE Unconstrained ¹			-10% GHGE			-20% GHGE			-30% GHGE			-40% GHGE			-50% GHGE		
		RD			RD			RD			RD			RD			RD		
		School 1	School 2	School 3	School 1	School 2	School 3	School 1	School 2	School 3	School 1	School 2	School 3	School 1	School 2	School 3	School 1	School 2	School 3
Main food category	Food subcategory																		
Eggs	Eggs, raw/prepared		3 items, -100%	2 items, -100%		3 items, -100%	2 items, -100%		3 items, -100%	2 items, -100%		3 items, -100%	2 items, -100%		3 items, -100%	2 items, -100%		3 items, -100%	2 items, -100%
Drinks (w/o) milk	Juice and nectar													-6%			-100%		
Fats and oils	Butter	-100%		1 item, -63% 1 item, -17%	-100%		-100%	-100%		-82%	-100%		-50%	-100%		-11%	-100%		1 item, -100% 1 item, +143%
	Margarine	-100%	-67%		-86%	-36%		-23%	-34%		+15%			+114%	+63%		+110%	+136%	
	Rapeseed oil		+33%	-100%			-100%			-100%			-100%			-98%			-100%
Seafood	Salmon																		+128%
	White fish																+95%		-53%
Fruits and berries	Berries																		+171%
Vegetables and roots	Legumes			+321%			+380%			+429%			+475%			+496%			+468%
	Potatoes and roots	+112%	+45%		+124%	+128%		+168%	+159%		+221%	+192%			+289%			+84%	
	Tomatoes, cucumbers, peppers																-100%		
Meat	Beef										1 item, -100% 1 item, -37%			-100%	2 items, -100%	-100%	-100%	2 items, -100%	2 items, -100%
	Meat balls/patties				-100%			2 items, -100%	-79%		4 items, -100%	-100%	-100%	4 items, -100% 1 item, -91%	-100%	2 items, -100%	8 items, -100%	2 items, -100%	2 items, -100%
	Meat dish																-100%		
	Minced meat					-60%	-52%		-100%	-94%		-100%	1 item, -100% 1 item, -71%		-100%	2 items, -100%		2 items, -100%	2 items, -100%
	Offal	+112%	+767%		+171%	+830%		+182%	+916%		+202%	+970%		+137%	+1021%		+89%	+867%	
	Pork																3 items, -100%	-100%	-100%
	Poultry													-11%	-44%		1 item, -100% 1 item, -1%	-100%	
	Sausages	-100%			-99%			-100%			2 items, -100%			2 items, -100%	-100%	-75%	3 items, -100%	1 item, -100% 1 item, -44%	2 items, -100%
	Vegetable dish with meat													-100%			2 items, -100%		
Seasoning and sauces	Mayonnaise/dressing			-29%			-10%			-5%			-1%				-50%		-23%
	Salt	-29%		-20%	-29%		-17%	-27%		-16%	-18%		-13%			-17%			
Dairy	Cheese	-11%	2 items, -100%	-100%		2 items, -100%	-100%	-96%	2 items, -100%	-100%	-100%	2 items, -100%	-100%	1 item, -100% 1 item, -62%	2 items, -100%	-100%	5 items, -100%	3 items, -100%	-100%
	Cream	-100%	2 items, -100%	-100%	-100%	1 item, -100% 1 item, -94%	-100%	-100%	1 item, -100% 1 item, -31%	-100%	-84%	1 item, -100% 1 item, -75%	-100%	2 items, -100%	1 item, -100% 1 item, -95%	-100%	3 items, -100%	2 items, -100%	2 items, -100%
	Milk	+51%	+74%	+289%	+45%	+56%	+250%	-15%	+55%	+247%	-3%	+35%	+248%	-40%		+242%	-33%	1 item, -100% 1 item, -1%	+140%
Nuts and seeds																			
Sugar and sweets																			
Cereals	Bread													+500%			+810%	+529%	
	Rice			-100%			-100%			-100%			-100%			-100%			-100%
	Flour or starch															-43%			

Figure S1. Summary of the RD for individual food items when minimizing TRD while applying constraints on nutritional adequacy and relative GHGE reductions (Model 2, TRD_{min}). ¹No constraint on maximum allowed amount of greenhouse gas emissions per meal; GHGE, Greenhouse gas emissions; RD, Relative deviation of individual food items from observed food supply after optimization, according to main food categories and food subcategories; TRD, Total relative deviation; TRD_{min}, optimized for minimum total relative deviation with unconstrained RD individual foods.

GHGE Unconstrained ¹					-10% GHGE			-20% GHGE			-30% GHGE			-40% GHGE							
RD					RD			RD			RD			RD							
		School 1	School 2	School 3	School 1	School 2	School 3	School 1	School 2	School 3	School 1	School 2	School 3	School 1	School 2	School 3					
Main food category	Food subcategory																				
Eggs	Eggs, raw/prepared		3 items, +200%	2 items, +200%			3 items, +200%	2 items, +200%			3 items, +200%	2 items, +200%		+75%	3 items, +200%	2 items, +200%					
Drinks (w/o) milk	Juice and nectar														3 items, -75%						
Fats and oils	Butter	-75%		-75%	-75%		1 item, -75%	1 item, -16%	-75%		1 item, -75%	1 item, +20%	-75%		1 item, -75%	1 item, +21%	-75%		1 item, -75%	1 item, +85%	
	Margarine	-75%	-36%		-75%				-37%	+24%			+49%	+27%		+103%	+120%				
	Rapeseed oil			1 item, -75%	1 item, -51%		-48%	1 item, -75%	1 item, -56%		-75%	1 item, -75%	1 item, -51%		-75%	1 item, -52%	1 item, -52%	-8%	-75%	1 item, -75%	1 item, -60%
Seafood	Salmon			+200%			+200%			+200%					+199%					+200%	
	White fish														-17%				-75%		
Fruits and berries	Berries														+64%					+174%	
	Exotic fruits															-75%					
Vegetables and roots	Legumes		+200%	1 item, +200%		1 item, +200%	1 item, +200%		1 item, +200%	2 items, +200%		2 items, +200%	1 item, +190%	2 items, +200%			3 items, +200%	1 item, +190%	2 items, +200%		
	Potatoes and roots	+119%		1 item, +168%		+140%	1 item, +85%	1 item, +123%		+182%	1 item, +114%			+200%			+103%	+61%			
	Tomatoes, cucumbers, peppers																-75%				
	Tomatoes, processed																			-75%	
Meat	Beef														2 items, -75%	-75%	-75%	2 items, -75%	3 items, -75%	3 items, -75%	
	Lamb																			-75%	
	Meat balls/patties				1 item, -75%	-62%			3 item, -75%	-75%	-50%	5 item, -75%	-75%	2 items, -75%			8 items, -75%	3 items, -75%	3 items, -75%	3 items, -75%	
	Meat dish				1 item, -34%				1 item, -12%								-75%				
	Minced meat		+79%	-46%						-60%	-75%		-75%	2 items, -75%				2 items, -75%	2 items, -75%	2 items, -75%	
	Offal	+159%	+200%			+170%	+200%			+187%	+200%			+192%	+200%			+111%	+200%		
	Pork																2 items, -75%	1 item, -75%	1 item, -25%	-75%	
	Poultry		-2%							-47%			-75%	-75%			2 items, -75%	-75%			
	Sausages	-75%	1 item, -75%	1 item, +87%	-75%	-75%	-75%	-75%	2 items, -75%	-75%	-75%	2 items, -75%	-75%	-75%			3 items, -75%	2 items, -75%	1 item, -73%	3 items, -75%	1 item, -71%
	Vegetable dish with meat										-75%					2 items, -75%					
Seasoning and sauces	Mayonnaise/dressing			-75%			-75%			-75%			-75%				-75%			-75%	
	Salt	-33%		-16%	-28%		-18%		-23%		-15%		-20%		-9%						
	Ketchup, mustard		+200%			+200%				+200%			+200%				-75%	+200%			
Dairy	Cheese	2 items, -75%	4 items, -75%	-75%	1 item, -75%	3 items, -75%	-75%	2 items, -75%	3 items, -75%	-75%	4 items, -75%	3 items, -75%	-75%		6 items, -75%	4 items, -75%	2 items, -75%				
	Cream	3 items, -75%	3 items, -75%	1 item, -75%	2 items, -75%	3 items, -75%	2 items, -75%	2 items, -75%	2 items, -75%	2 items, -75%	3 items, -75%	2 items, -75%	-75%		3 items, -75%	3 items, -75%	2 items, -75%				
	Milk	+39%	1 item, -75%	1 item, +200%	+39%	+37%	1 item, +200%	+21%	+25%	+3%	1 item, -56%	+25%	+200%		-35%				+168%		
	Yoghurt and sour milk		-75%	1 item, +68%		-75%	1 item, +119%		-75%			-61%					-75%	-75%			
Nuts and seeds	Nut or seed product	-34%																			
Sugar and sweets																					
Cereals	Bread					+200%			+200%		+68%	+200%			2 items, +200%	1 item, +200%	1 item, +127%				
	Breakfast cereals		+200%			+200%			+200%	+8%		+200%	+17%			+200%					
	Flour or starch					-22%							-16%							-22%	
	Grains and bran					+200%			+200%			+200%				+200%					
	Pasta, bulgur, couscous etc.								+200%			+200%				+200%					
	Rice		-75%	-75%		-75%	-75%		-75%	-75%		-67%	-75%		-75%	-75%	-75%				

Figure S2. Summary of the RD for individual food items when minimizing TRD while applying constraints on nutritional adequacy, relative GHGE reductions, and additional constraints on the RD of individual food items (Model 3, CRD_{min}).¹No constraint on maximum allowed amount of carbon dioxide equivalents (CO₂eq) per optimized food supply; GHGE, Greenhouse gas emissions; TRD, Total relative deviation; RD, Relative deviation of individual food items from baseline food supply after optimization, according to main food categories and food subcategories; CRD_{min}, optimized for minimum total relative deviation while constraining the relative deviation of individual food items to a range between -75% and +200%.