

Nutritional issues and dietary levers during gradual meat reduction - a sequential diet optimization study to achieve progressively healthier diets

Dussiot *et al.*

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SUPPLEMENTAL TABLE 1 Lifestyle and sociodemographic characteristics of the sample of adults ($n = 125$) extracted from the French national INCA3 study, 2014-2015

	Males ($n = 564$)	Females ($n = 561$)
Age, %		
< 25y	9%	8%
25-35y	16%	25%
35-50y	38%	52%
50-65y	37%	15%
Level of education, %		
< High-school diploma	34%	23%
High-school diploma	21%	21%
Post-secondary education	44%	56%
Body Mass Index, %		
< 18.5 kg.m ⁻²	2%	4%
18.5-24.99 kg.m ⁻²	49%	59%
25-29.99 kg.m ⁻²	38%	24%
> 30 kg.m ⁻²	11%	12%
Alcohol consumption, %		
Non-drinker	30%	54%
Moderate drinker ¹	70%	46%
Heavy drinker ²	-	-

¹ <20g/d for females and <30 g/d for males

² >20g/d for females and >30 g/d for males (1)

SUPPLEMENTAL TABLE 2 Summary of foods groups formed for food categorization

Food category (Number of food items per category)	Food group (Number of food items per group)	Proportion of food group within the category	Main types of foods (Proportion of foods within the group)
Fruit and vegetables (244)	Vegetables (149)	61%	Raw vegetables (~ 40%) Cooked vegetables (~ 30%)
	Fresh fruits (50)	20%	Raw fruits (100%)
	Dried fruits (9)	4%	Dried fruits (70%) Chestnuts (30%)
	Processed fruits: compotes and cooked fruit (13)	5%	Compote (40%) Fruit in syrup (40%)
	Nuts, seeds and oleaginous fruits (23)	9%	Oleaginous fruits (~ 50%) Seeds (~ 40%)
Starches (171)	Bread and refined bakery products (36)	21%	Breads (~ 50%) Rusks (~ 20%)
	Whole meal and semi-refined bread and bakery products (15)	9%	Breads (~ 50%) Rusks (~ 30%)
	Other refined starches (13)	8%	Rice (~ 30%) Pasta (~ 20%)
	Other complete and semi- complete starches (11)	6%	Wheat (50%) Quinoa (20%)
	Starch-based products, sweet/fat processed (61)	36%	Breakfast cereals (~ 50%) Cookies (~ 20%)
	Salt/fat processed starch products (15)	9%	Savory cookies (~ 50%) Chips: 4 foods (~ 20%)
	Potatoes and other tubers (20)	12%	Potatoes (~ 50%) Other tubers (~ 20%)
Legumes (16)	Legumes (16)	100%	Dried beans (~ 50%) Lentils (15%)

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Food category (Number of food items per category)	Food group (Number of food items per group)	Proportion within the category	Main types of foods (Proportion of food within the group)
Meats, Processed meats, Fish products, Eggs (315)	Poultry (24)	8%	Chicken (~ 30%) Duck (~ 20%)
	Beef and veal (40)	13%	Beef (~ 65%) Veal (~ 35%)
	Pork and other meats (39)	12%	Pork (~ 40%) Lamb (~ 30%)
	Offal (19)	6%	Beef and veal (~ 50%)
	Processed meats (71)	23%	Sausages, "andouilles" (~ 35%) "Rillettes", "pâtés", "terrines", "foie gras" (~ 35%)
	Oily fish (32)	10%	Salmon (~ 30%) Mackerel (~ 20%)
	Other fish (55)	17%	Tuna (~ 15%) Trout (~ 10%)
	Mollusks and crustaceans (21)	7%	Mollusks excluding cephalopods (40%) Crustaceans (~ 30%)
	Eggs and egg-based dishes (14)	4%	Whole eggs (~ 65%) Egg yolks (~ 20%)
Milk and dairy products (192)	Milk (15)	8%	Semi-skimmed cow's milk (40%) Whole cow's milk (25%)
	Fresh natural dairy products (18)	9%	Yoghurts, fermented milks and dairy specialties (~ 55%) Cottage cheeses, "Faisselles", "Petit Suisse" (~ 45%)
	Fresh sweetened dairy products (39)	20%	Yoghurts, fermented milks and dairy specialties (~ 65%) Cottage cheeses, "Faisselles", "Petit Suisse" (~ 25%)
	Sweet milky desserts (22)	11%	Cream desserts (~ 60%) Other sweet desserts (~ 25%)
	Cheese (98)	51%	-

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Food category (Number of food items per category)	Food group (Number of food items per group)	Proportion within the category	Main types of foods (Proportion of food within the group)
Added fats and oils (98)	Animal fats and assimilated fats (4)	4%	Lard, bacon, duck or goose fat
	Butter and low-fat butter (11)	11%	Butter (55%) Low-fat butter (45%)
	Vegetable fats rich in alpha-linoleic acid (4)	4%	Vegetable oils (100%): rapeseed, flax, walnut, soybean
	Vegetable fats low in alpha-linoleic acid (24)	24%	Vegetable oils (peanut, sunflower, palm, frying) (33%) Vegetable fats (margarine type) (67%)
	Sauces and fresh creams (55)	56%	Hot sauces (80%) Cold sauces (ketchup, mustard, mayo, miso) (20%)
Sweet products or Sweet and fatty products (198)	Sweet products or sweet and fatty products (198)	100%	Pastries (~ 15%) Cookies (~ 10%)
Drinking water (44)	Drinking water (44)	100%	-
Alcohol-free soft drinks (74)	Sweetened soda-type drinks (45)	61%	-
	Fruit juices (29)	39%	-
Hot drinks (22)	Hot drinks (22)	100%	Coffee and related products (~ 60%) Tea and herbal teas (~ 30%)
Salt (6)	Salt (6)	100%	-
Condiments (13)	Condiments (13)	100%	Olives or similar (~ 50%) Vinegar products (~ 20%)
Aromatic herbs, Spices except salt (38)	Aromatic herbs, spices except salt (38)	100%	Aromatic herbs (~ 65%) Spices (35%)

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Food category (Number of food items per category)	Food group (Number of food items per group)	Proportion within the category	Main types of foods (Proportion of food within the group)
Soups and Bouillons (38)	Soups (30)	79%	Vegetable soups (with or without cheese) (85%) Soups with eggs, poultry or fish (15%)
	Bouillons (8)	21%	Broths with meat (75%) Vegetable broths only (25%)
Substitutes of animal products (9)	Substitutes for animal products (9)	100%	Soy products (~ 90%) Almond drink (~ 10%)
Other foods (14)	Other foods (14)	100%	Fish eggs (~ 40%) Vinegars (25%)
Alcoholic drinks (41)	Alcoholic drinks (41)	100%	-

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SUPPLEMENTAL TABLE 3. Daily intakes of nutrients in observed and modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

		Males											Lower bounds	Upper bounds
Nutrient	Unit	Observed diet	Modeled diet with gradual meat reduction (%) ¹											
			10%	20%	30%	40%	50%	60%	70%	80%	90%	100%		
Retinol	$\mu\text{g}\cdot\text{d}^{-1}$	573	496	450	396	354	345	334	331	331	330	330	-	3000
Vitamin A	$\mu\text{g}\cdot\text{d}^{-1}$	805	750 ²	750	750	769	764	753	750	750	750	750	750	-
Thiamin	$\mu\text{g}\cdot(\text{kcal}\cdot\text{d})^{-1}$	0.54	0.51	0.52	0.54	0.55	0.55	0.55	0.55	0.55	0.54	0.54	0.42	-
Riboflavin	$\text{mg}\cdot\text{d}^{-1}$	2.17	2.11	2.10	2.09	2.05	1.92	1.94	1.97	1.96	1.95	1.96	1.60	-
Niacin ³	$\mu\text{g NE}\cdot(\text{kcal}\cdot\text{d})^{-1}$	20	20	20	20	20	10	10	10	10	10	10	6.7	-
Pantothenic acid	$\text{mg}\cdot\text{d}^{-1}$	6.90	6.94	7.01	7.10	7.08	6.85	6.68	6.56	6.46	6.33	6.26	3.77	-
Vitamin B6	$\text{mg}\cdot\text{d}^{-1}$	2.06	2.04	2.12	2.23	2.28	2.32	2.24	2.18	2.13	2.07	2.03	1.70	25
Folate	$\mu\text{g}\cdot\text{d}^{-1}$	347	381	400	424	453	462	470	477	484	485	486	330	-
Vitamin B12	$\mu\text{g}\cdot\text{d}^{-1}$	6.15	5.62	5.37	5.14	4.97	5.69	5.75	6.19	6.09	6.02	6.15	4.00	-
Vitamin C	$\text{mg}\cdot\text{d}^{-1}$	98 ⁴	110	127	146	162	170	170	170	170	170	170	110	-
Vitamin D ⁵	$\mu\text{g}\cdot\text{d}^{-1}$	3.49	3.50	3.48	3.45	3.41	3.80	3.35	3.24	3.23	3.31	3.69	-	100
Vitamin E	$\text{mg}\cdot\text{d}^{-1}$	13	15	15	16	17	17	17	17	17	18	18	5.28	-
Vitamin K1	$\mu\text{g}\cdot\text{d}^{-1}$	118	150	169	191	216	218	219	219	220	220	220	39	-
Calcium	$\text{mg}\cdot\text{d}^{-1}$	1 065	1 028	1 035	1 042	1 051	1 049	1 056	1 059	1 070	1 081	1 096	950	2500
Copper	$\text{mg}\cdot\text{d}^{-1}$	2.08	2.19	2.17	2.18	2.20	2.16	2.25	2.36	2.40	2.40	2.38	1.99	5
Bioavailable Iron	$\text{mg}\cdot\text{d}^{-1}$	1.68	1.20	1.21	1.20	1.20	1.31	1.31	1.31	1.29	1.26	1.23	1.103	-
Iodine	$\mu\text{g}\cdot\text{d}^{-1}$	175	150	150	150	150	150	153	157	159	161	165	150	600
Magnesium	$\text{mg}\cdot\text{d}^{-1}$	409	465	470	480	485	446	459	472	479	478	476	254	-

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¹ In each x% modeled scenario, total meat consumption was reduced by at least x% of its observed value.

² In the modeled diets, the nutrient intakes that were limiting (*i.e.*, equal to their lower or upper bounds) are in white on a black background. In addition, for bioavailable iron and bioavailable zinc, for which the lower bounds were set at the security thresholds, intakes lower than reference value are on a grey background.

³ 1 mg niacin equivalent (NE) is equal to 1mg niacin or 60 mg tryptophan.

⁴ In the observed diet, nutrient intakes not complying with the nutritional constraints (*i.e.*, not between the lower and upper bounds) are in bold. For bioavailable iron and bioavailable zinc, for which the lower bounds were set at the security thresholds, bold indicate a value lower than the reference value.

⁵ One exception was vitamin D, for which we did not set any lower constraint; based on previous works, the reference value is known to be much too high to permit a solution from diet optimization (2,3).

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		Males											Lower bounds	Upper bounds
Nutrient	Unit	Observed diet	Modeled diet with gradual meat reduction (%)											
			10%	20%	30%	40%	50%	60%	70%	80%	90%	100%		
Manganese	mg·d ⁻¹	3.61	4.44	4.61	4.80	5.00	4.99	5.24	5.50	5.69	5.73	5.74	1.99	-
Phosphorus	mg·d ⁻¹	1 483	1 462	1 488	1 519	1 536	1 565	1 562	1 560	1 556	1 535	1 516	550	-
Potassium	mg·d ⁻¹	3 736	3 984	4 061	4 221	4 356	4 143	4 131	4 120	4 104	4 079	4 059	3500	-
Selenium	µg·d ⁻¹	146	127	130	132	133	126	130	132	131	130	125	70	300
Sodium	mg·d ⁻¹	3 938	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	1500	2300
Bioavailable zinc	mg·d ⁻¹	3.57	2.89	2.88	2.87	2.84	2.83	2.83	2.84	2.80	2.77	2.74	2.063	25
Water	g·d ⁻¹	2 780	2 643	2 686	2 735	2 754	2 503	2 510	2 516	2 522	2 520	2 516	2500	-
Saturated fatty acids	%EI·d ⁻¹	14%	12%	12%	12%	11%	11%	11%	10%	10%	11%	11%	-	12%
Lauric+myristic+palmitic acids	%EI·d ⁻¹	8%	8%	7%	7%	7%	7%	7%	7%	7%	7%	7%	-	8%
Linoleic acid	%EI·d ⁻¹	3%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	-
α-linolenic acid	%EI·d ⁻¹	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	-
Linoleic acid / α-linolenic acid ratio	-	7.90	4.09	4.06	4.02	3.96	3.89	3.91	3.90	3.87	4.00	4.00	-	5
EPA+DHA ¹	g·d ⁻¹	0.33	0.51	0.50	0.50	0.50	0.65	0.50	0.50	0.50	0.51	0.65	0.50	-
Sugar excluding lactose	g·d ⁻¹	102	100	100	100	100	100	100	100	100	100	100	-	100
Protein ²	g·d ⁻¹	103	90	91	93	91	90	88	86	84	80	77	64	179
Fiber	g·d ⁻¹	23	30	32	34	36	37	38	39	40	40	40	30	-

¹ DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid.

² Intakes (mg/d) were converted to mg/kg body weight/day for a mean body weight of 77.4 kg for males. To account for the slightly lower average digestibility of plant protein, protein intake from plants was reduced by 5% when calculating total protein intake, as previously described in the Methods section (L122-L123).

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SUPPLEMENTAL TABLE 3 cont. Daily intakes of limiting nutrients in observed and modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

		Females											Lower bounds	Upper bounds
Nutrient	Unit	Observed diet	Modeled diet with gradual meat reduction (%) ¹											
			10%	20%	30%	40%	50%	60%	70%	80%	90%	100%		
Retinol	$\mu\text{g}\cdot\text{d}^{-1}$	395	378	409	302	295	293	290	288	285	282	275	-	3000
Vitamin A	$\mu\text{g}\cdot\text{d}^{-1}$	608	650 ²	711	650	703	698	694	689	685	681	674	650	-
Thiamin	$\mu\text{g}\cdot(\text{kcal}\cdot\text{d})^{-1}$	0.56	0.56	0.56	0.55	0.57	0.57	0.56	0.56	0.55	0.55	0.54	0.42	-
Riboflavin	$\text{mg}\cdot\text{d}^{-1}$	1.66	1.90	1.89	1.67	1.73	1.72	1.72	1.72	1.71	1.70	1.69	1.60	-
Niacin ³	$\mu\text{g NE}\cdot(\text{kcal}\cdot\text{d})^{-1}$	20	20	20	10	10	10	10	10	10	10	10	6.7	-
Pantothenic acid	$\text{mg}\cdot\text{d}^{-1}$	5.29	6.29	6.35	6.05	6.26	6.18	6.11	6.05	5.97	5.88	5.81	3.20	-
Vitamin B6	$\text{mg}\cdot\text{d}^{-1}$	1.51 ⁴	1.84	1.87	1.90	1.98	1.93	1.89	1.86	1.82	1.77	1.74	1.60	25
Folate	$\mu\text{g}\cdot\text{d}^{-1}$	280	359	370	377	419	421	425	430	432	432	433	330	-
Vitamin B12	$\mu\text{g}\cdot\text{d}^{-1}$	4.14	4.90	5.32	5.00	5.31	5.79	6.54	6.57	6.51	6.45	6.39	4.00	-
Vitamin C	$\text{mg}\cdot\text{d}^{-1}$	84	110	110	125	149	147	146	145	144	143	143	110	-
Vitamin D ⁵	$\mu\text{g}\cdot\text{d}^{-1}$	2.87	3.54	3.58	3.66	3.64	3.59	3.51	3.48	3.47	3.47	3.47	-	100
Vitamin E	$\text{mg}\cdot\text{d}^{-1}$	11	13	14	14	15	15	15	15	15	15	15	4.37	-
Vitamin K1	$\mu\text{g}\cdot\text{d}^{-1}$	111	150	169	216	218	218	218	218	218	219	219	35	-
Calcium	$\text{mg}\cdot\text{d}^{-1}$	892	983	988	974	1 006	1 010	1 015	1 018	1 019	1 020	1 021	950	2500
Copper	$\text{mg}\cdot\text{d}^{-1}$	1.56	1.99	2.10	1.82	1.96	2.03	2.13	2.18	2.21	2.22	2.23	0.89	5
Bioavailable Iron	$\text{mg}\cdot\text{d}^{-1}$	1.21	1.16	1.16	1.17	1.22	1.22	1.22	1.21	1.20	1.19	1.17	1.16	-
Iodine	$\mu\text{g}\cdot\text{d}^{-1}$	145	150	150	150	150	153	158	160	160	160	160	150	600
Magnesium	$\text{mg}\cdot\text{d}^{-1}$	330	436	434	384	410	418	427	437	441	442	443	195	-

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¹ In each x% modeled scenario, the total meat consumption was reduced by at least x% of its observed value.

² In the modeled diets, nutrient intakes that were limiting (*i.e.*, equal to their lower or upper bounds) are in white on a black background. In addition, for bioavailable iron and bioavailable zinc, for which the lower bounds were set at the security thresholds, intakes lower than reference value are on a grey background.

³ 1 mg niacin equivalent (NE) is equal to 1mg niacin or 60 mg tryptophan.

⁴ In the observed diet, nutrient intakes not complying with the nutritional constraints (*i.e.*, not between the lower and upper bounds) are in bold. For bioavailable iron and bioavailable zinc, for which the lower bounds were set at the security thresholds, bold indicate a value lower than the reference value.

⁵ One exception was vitamin D, for which we did not set any lower constraint; based on previous works, the reference value is known to be much too high to permit a solution from diet optimization (2,3).

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		Females												
Nutrient	Unit	Observed diet	Modeled diet with gradual meat reduction (%)										Lower bounds	Upper bounds
			10%	20%	30%	40%	50%	60%	70%	80%	90%	100%		
Manganese	mg·d ⁻¹	3.06	4.34	4.40	4.14	4.47	4.61	4.77	4.97	5.10	5.16	5.24	1.50	-
Phosphorus	mg·d ⁻¹	1 128	1 340	1 375	1 408	1 438	1 436	1 436	1 440	1 433	1 418	1 407	550	-
Potassium	mg·d ⁻¹	2 906	3 799	3 809	3 500	3 786	3 772	3 760	3 752	3 738	3 718	3 703	3500	-
Selenium	µg·d ⁻¹	120	119	122	130	123	124	125	125	123	122	120	70	300
Sodium	mg·d ⁻¹	3 100	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	2 300	1500	2300
Bioavailable zinc	mg·d ⁻¹	3.15	2.86	2.83	2.75	2.79	2.81	2.85	2.83	2.80	2.77	2.75	1.614	25
Water	g·d ⁻¹	2 422	2 454	2 395	2 120	2 215	2 209	2 206	2 208	2 203	2 194	2 187	2000	-
Saturated fatty acids	%EI·d ⁻¹	15%	12%	12%	12%	11%	11%	11%	11%	11%	11%	11%	-	12%
Lauric+myristic+palmitic acids	%EI·d ⁻¹	9%	8%	7%	7%	7%	7%	7%	7%	7%	7%	7%	-	8%
Linoleic acid	%EI·d ⁻¹	3%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	4%	-
α-linolenic acid	%EI·d ⁻¹	0%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	1%	-
Linoleic acid / α-linolenic acid ratio	-	7.24	4.12	4.13	4.15	4.08	4.06	4.05	4.04	4.02	4.00	3.97	-	5
EPA+DHA ¹	g·d ⁻¹	0.22	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	0.50	-
Sugar excluding lactose	g·d ⁻¹	80	100	100	100	100	100	100	100	100	100	100	-	100
Protein ²	g·d ⁻¹	76	81	83	82	82	80	79	78	76	74	72	55	152
Fiber	g·d ⁻¹	19	30	32	32	35	35	36	37	38	38	39	30	-

¹ DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid.

² Intakes (mg/d) were converted to mg/kg body weight/day for a mean body weight of 66.0 kg for females. To account for the slightly lower average digestibility of plant protein, protein intake from plants was reduced by 5% when calculating total protein intake, as previously described in the Methods section (L122-L123).

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SUPPLEMENTAL TABLE 4. Summary of constraints and criteria for each food group in the diet optimization model for males and females

Food group	Optimization Objective (HDP criterion)	Males				Females			
		Observed consumption (g/d)	Constraint			Observed consumption (g/d)	Constraint		
			Lower limit ¹ (g/d)	Upper limit (g/d)	Joint upper limit (g/d)		Lower limit (g/d)	Upper limit (g/d)	Joint upper limit (g/d)
Vegetables	Maximization	176	20	400	-	160	18	387	-
Fresh fruits	Maximization	128	0	-	454 ²	107	0	-	359
Dried fruits		1	0	-		1	0	-	
Processed fruits: compotes and cooked fruit		13	0	-		15	0	-	
Nuts, seeds and oleaginous fruit		3	0	20		2	0	14	
Bread and refined bakery products	Maximization	168	27	-	-	115	10	-	-
Complete and semi-complete bread and bakery products		11	0	-	-	15	0	-	-
Other refined starches		98	0	-	-	72	0	-	-
Other complete and semi-complete starches		4	0	-	-	4	0	-	-
Starch-based products, sweet/fat processed		22	0	97	-	19	0	82	-
Salt/fat processed starch products		4	0	21	-	2	0	14	-
Potatoes and other tubers	Maximization	79	0	264	-	49	0	196	-
Legumes		13	0	86	-	6	0	43	-
Poultry		30	0	108	-	31	0	109	-
Beef and veal	Minimization	48	0	-	71	28	0	-	71
Pork and other meats		27	0	-		13	0	-	
Offal		4	0	-		1	0	-	
Processed meat		50	0	25		30	0	25	
Oily fish ³	Minimization	8	0	26	-	6	0	26	-
Other fish ³		22	0	110	-	15	0	80	-

¹ Lower and upper limits correspond to the 5th or 95th percentiles of consumption for all food groups except those with an upper limit set as a dietary constraint (red meat, processed meat and soft drinks).

² The most substitutable food groups were grouped together to define their lower and upper bounds as the 5th or 95th percentiles of their total consumption.

³ In order to consider the French dietary recommendations for fish consumption, two additional constraints were added to limit total fish consumption to 39 g/d and oily fish consumption to 26 g/d (4).

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Food group	Optimization Objective (HDP criterion)	Males				Females			
		Observed consumption (g/d)	Constraint			Observed consumption (g/d)	Constraint		
			Lower limit (g/d)	Upper limit (g/d)	Upper Joint limit (g/d)		Lower limit (g/d)	Upper limit (g/d)	Upper joint limit (g/d)
Mollusks and crustaceans		5	0	28	-	4	0	26	-
Eggs and egg-based dishes		14	0	61	-	14	0	70	-
Milk		84	0	343	-	75	0	322	-
Fresh natural dairy products		31	0	138	-	33	0	143	-
Fresh sweetened dairy products		50	0	179	-	48	0	168	-
Sweet milky desserts		19	0	93	-	16	0	73	-
Cheeses		49	0	131	-	36	0	94	-
Animal fats and assimilated fats		1	0	0	-	0	0	0	-
Butter and light butter		10	0	33	-	10	0	30	-
Vegetable fats rich in α -linoleic acid		0	0	-	32	0	0	-	30
Vegetable fats rich in α -linoleic acid		12	0	-		10	0	-	
Sauces and fresh creams		35	0	118	-	32	0	100	-
Sweet products or sweet and fatty products		103	9	251	-	83	9	215	-
Drinking water		1007	182	-	-	929	75	-	-
Sweetened soda-type drinks	Minimization	141	0	-	263	140	0	-	263
Fruit juices		80	0	-		67	0	-	
Hot drinks		494	0	494	-	507	0	507	-
Salt		1	0	4	-	1	0	4	-
Condiments		4	0	29	-	3	0	21	-
Aromatic herbs, Spices except salt		2	0	7	-	2	0	6	-
Soups		71	0	434	-	75	0	381	-
Bouillons		5	0	21	-	4	0	25	-

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Food group	Optimization Objective (HDP criterion)	Males				Females			
		Observed consumption (g/d)	Constraint			Observed consumption (g/d)	Constraint		
			Lower limit (g/d)	Upper limit (g/d)	Upper joint limit (g/d)		Lower limit (g/d)	Upper limit (g/d)	Upper joint limit (g/d)
Substitutes for animal products		3	0	29	-	5	0	29	-
Other foods		4	4	4	-	2	2	2	-
Alcoholic drinks		216	0	216	-	59	0	59	-
Bread and bakery products		178	-	354	-	130	-	316	-
Other starches		102	-	276	-	76	-	188	-
Liquids		2098	1061	3777	-	1857	738	3087	-

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SUPPLEMENTAL TABLE 5. Absolute and relative changes in daily food group consumptions under observed (Obs) and modeled diets as optimized to be healthier while taking account of dietary inertia ¹ during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females) ²

	Males										
	Observed diet	Modeled diet with gradual meat reduction (%) ³									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Diet composition, g/d											
Fruits and vegetables	318	448	571	701	816	854	854	854	854	854	854
Refined grain products	266	27	27	27	27	27	27	27	27	27	27
Whole grain products	14	217	225	236	255	281	312	346	369	372	373
Red meat	79	10	7	5	3	2	2	1	1	1	0
Processed meat	50	0	0	0	0	0	0	0	0	0	0
Poultry	30	95	98	102	93	78	62	47	31	15	0
Seafood	36	35	35	37	39	47	53	59	59	59	59
Dairy products	233	245	248	250	253	280	277	272	276	282	291
Soft drinks	221	78	50	35	27	22	20	18	17	15	14
Eggs	14	17	17	18	19	21	22	23	24	25	28
Legumes and nuts	17	18	18	18	18	18	18	18	18	19	19
Potatoes and starch-based products	106	110	109	109	111	115	115	114	116	117	119
Added fats	58	61	59	58	58	57	57	56	56	56	57
Other drinks	1717	1689	1630	1560	1475	1150	1148	1144	1142	1141	1138
Others	192	108	107	95	81	73	72	72	72	73	73

¹ Dietary inertia was modeled using the *Diet Departure* criterion.

² Data are averages for each sex.

³ In each x% modeled scenario, total meat consumption was diminished by at least x% of its observed value. For clarity, the 45 modeled food groups are not shown here but were grouped into broader categories included in the *Healthy Dietary Pattern* criterion (such as red meat, processed meat, soft drinks, grain products, fruits and vegetables) or that represent other protein sources (such as poultry, seafood, dairy products, eggs, legumes and nuts). The remaining food groups were grouped as "others" (8 groups) and "other drinks" (3 groups). Detailed food categories are presented in Supplemental Table 2.

Online Supplementary Material

	Males										
	Observed diet	Modeled diet with gradual meat reduction (%)									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Differences from observed diets, %⁴											
Δ Fruits and vegetables	-	41%	27%	23%	16%	5%	0%	0%	0%	0%	0%
Δ Refined grain products	-	-90%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Δ Whole grain products	-	1397%	4%	5%	8%	10%	11%	11%	7%	1%	0%
Δ Red meat	-	-88%	-25%	-36%	-41%	-28%	-24%	-18%	-14%	-31%	-98%
Δ Processed meat	-	-100%	-	-	-	-	-	-	-	-	-
Δ Poultry	-	213%	3%	4%	-9%	-16%	-20%	-25%	-34%	-51%	-100%
Δ Seafood	-	-2%	2%	3%	6%	23%	12%	11%	0%	0%	0%
Δ Dairy products	-	5%	1%	1%	1%	11%	-1%	-2%	1%	2%	3%
Δ Soft drinks	-	-65%	-36%	-29%	-24%	-17%	-11%	-9%	-8%	-8%	-7%
Δ Eggs	-	18%	4%	4%	5%	14%	3%	3%	6%	7%	9%
Δ Legumes and nuts	-	11%	-1%	0%	1%	1%	0%	-1%	1%	2%	1%
Δ Potatoes and starch-based products	-	4%	-1%	0%	2%	3%	0%	-1%	1%	2%	1%
Δ Added fats	-	6%	-2%	-2%	0%	-1%	-1%	-2%	0%	1%	2%
Δ Other drinks	-	-2%	-3%	-4%	-5%	-22%	0%	0%	0%	0%	0%
Δ Others	-	-44%	0%	-11%	-15%	-10%	0%	-1%	1%	1%	0%

⁴ Percent increase or decrease at each step is relative to the observed diet.

Online Supplementary Material

SUPPLEMENTAL TABLE 5 cont. Absolute and relative changes in daily food group consumptions under observed (Obs) and modeled diets as optimized to be healthier while taking account of dietary inertia ¹ during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, *n*=564 males and *n*=561 females) ²

	Females										
	Observed diet	Modeled diet with gradual meat reduction (%) ³									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Diet composition, g/d											
Fruits and vegetables	283	402	498	629	746	746	746	746	746	746	746
Refined grain products	186	10	10	10	10	10	10	10	10	10	10
Whole grain products	19	215	222	236	246	263	281	306	321	327	335
Red meat	42	14	8	0	0	0	0	0	0	0	0
Processed meat	30	7	6	5	4	4	3	3	3	2	0
Poultry	31	62	69	67	58	48	38	28	18	8	0
Seafood	25	38	43	50	53	57	63	63	63	63	63
Dairy products	208	252	256	282	284	283	281	279	279	278	278
Soft drinks	208	135	69	48	37	31	26	23	20	18	17
Eggs	14	20	23	26	28	29	30	31	32	34	35
Legumes and nuts	8	10	10	10	10	10	10	10	10	10	10
Potatoes and starch-based products	71	78	80	81	81	81	80	80	80	80	80
Added fats	53	51	49	48	47	46	45	44	44	43	43
Other drinks	1495	1478	1388	966	964	963	961	960	959	958	957
Others	174	143	130	127	119	114	109	107	104	102	101

¹ Dietary inertia was modeled using the Diet Departure criterion.

² Data are averages for each sex.

³ In each x% modeled scenario, total meat consumption was diminished by at least x% of its observed value. For clarity, the 45 modeled food groups are not shown here but were grouped into broader categories included in the Healthy Dietary Pattern criterion (such as red meat, processed meat, soft drinks, grain products, fruits and vegetables) or that represent other protein sources (such as poultry, seafood, dairy products, eggs, legumes and nuts). The remaining food groups were grouped as "others" (8 groups) and "other drinks" (3 groups). Detailed food categories are presented in Supplemental Table 2.

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	Females										
	Observed diet	Modeled diet with gradual meat reduction (%)									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Differences from observed diets, %⁴											
Δ Fruits and vegetables	-	42%	24%	26%	19%	0%	0%	0%	0%	0%	0%
Δ Refined grain products	-	-95%	0%	0%	0%	0%	0%	0%	0%	0%	0%
Δ Whole grain products	-	1013%	4%	6%	4%	7%	7%	9%	5%	2%	2%
Δ Red meat	-	-68%	-40%	-97%	-7%	-8%	-10%	-12%	-18%	-32%	-100%
Δ Processed meat	-	-77%	-14%	-13%	-13%	-12%	-12%	-12%	-14%	-22%	-99%
Δ Poultry	-	98%	11%	-3%	-14%	-17%	-21%	-26%	-35%	-54%	-100%
Δ Seafood	-	52%	11%	18%	6%	7%	10%	1%	0%	0%	0%
Δ Dairy products	-	21%	2%	10%	1%	0%	-1%	0%	0%	0%	0%
Δ Soft drinks	-	-35%	-49%	-30%	-23%	-18%	-15%	-12%	-11%	-10%	-9%
Δ Eggs	-	49%	11%	17%	5%	4%	3%	4%	4%	4%	5%
Δ Legumes and nuts	-	25%	1%	1%	-1%	0%	0%	0%	0%	0%	1%
Δ Potatoes and starch-based products	-	11%	2%	2%	-1%	0%	0%	0%	0%	0%	0%
Δ Added fats	-	-3%	-4%	-2%	-3%	-2%	-2%	-1%	-1%	-1%	-1%
Δ Other drinks	-	-1%	-6%	-30%	0%	0%	0%	0%	0%	0%	0%
Δ Others	-	-18%	-9%	-2%	-7%	-4%	-4%	-3%	-2%	-2%	-2%

⁴ Percent increase or decrease at each step is relative to the observed diet.

Online Supplementary Material

SUPPLEMENTAL TABLE 6. Relative changes to total and detailed daily meat consumption by type (processed meat, pork and other meats, offal, beef and veal, poultry) under modeled diets as optimized to be healthier while taking account of dietary inertia ¹ during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

	Men										
	Observed diet	Modeled diet with gradual meat reduction (%) ²									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Max. allowed meat consumption, g/d	-	144	128	112	96	80	64	48	32	16	0
Optimized meat consumption, g/d	160	105	106	107	96	80	64	48	32	16	0
Differences to observed diets, % ³											
Total meat consumption	-	-34%	-34%	-33%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
Processed meat	-	-100%	-	-	-	-	-	-	-	-	-
Pork and other meats	-	-100%	-	-	-	-	-	-	-	-	-
Offal	-	163%	96%	26%	-26%	-47%	-59%	-66%	-71%	-80%	-100%
Beef and veal	-	-100%	-	-	-	-	-	-	-	-	-
Poultry	-	213%	223%	237%	206%	156%	105%	53%	2%	-50%	-100%

¹ Dietary inertia was modeled using the Diet Departure criterion.

² In each x% modeled scenario, total meat consumption was diminished by at least x% of its observed value. Total meat consumption at the bound (*i.e.*, corresponding to a limiting constraint) is in white on a black background.

³ Percent increase or decrease at each step is relative to the observed diet.

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SUPPLEMENTAL TABLE 6 cont. Relative changes to total and detailed daily meat consumption by type (processed meat, pork and other meats, offal, beef and veal, poultry) under modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

	Women										
	Observed diet	Modeled diet with gradual meat reduction (%) ²									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Max. allowed total meat consumption, g/d	-	93	83	73	62	52	42	31	21	10	0
Optimized total meat consumption, g/d	104	83	83	73	62	52	42	31	21	10	0
Differences to observed diets, % ³											
Total meat consumption	-	-20%	-20%	-30%	-40%	-50%	-60%	-70%	-80%	-90%	-100%
Processed meat	-	427%	353%	295%	244%	203%	167%	135%	101%	57%	-99%
Pork and other meats	-	-100%	-	-	-	-	-	-	-	-	-
Offal	-	246%	399%	-83%	-85%	-86%	-87%	-89%	-91%	-94%	-100%
Beef and veal	-	-68%	-94%	-100%	-	-	-	-	-	-	-
Poultry	-	98%	120%	114%	83%	52%	21%	-11%	-43%	-74%	-100%

¹ Dietary inertia was modeled using the Diet Departure criterion.

² In each x% modeled scenario, total meat consumption was diminished by at least x% of its observed value. Total meat consumption at the bound (*i.e.*, corresponding to a limiting constraint) is in white on a black background.

³ Percent increase or decrease at each step is relative to the observed diet.

Online Supplementary Material

SUPPLEMENTAL TABLE 7. Absolute daily food group consumptions under modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

Diet composition, g/d	Males											
	Observed diet	Modeled diet with gradual meat reduction (%)										
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	
Vegetables	176	235	279	333	400	400	400	400	400	400	400	400
Fresh fruits	128	194	286	368	416	453	453	452	452	453	453	453
Dried fruits	1	19	5	0	0	0	0	1	1	0	0	0
Processed fruits: compotes and cooked fruits	13	0	0	0	0	0	0	0	0	0	0	0
Nuts, seeds and oleaginous fruits	3	3	3	3	3	3	3	3	3	3	3	3
Bread and refined bakery products	168	27	27	27	27	27	27	27	27	27	27	27
Complete and semi-complete bread and bakery products	11	99	97	94	93	92	93	90	92	96	97	97
Other refined starches	98	0	0	0	0	0	0	0	0	0	0	0
Other complete and semi-complete starches	4	118	128	142	162	190	219	255	276	276	276	276
Starch-based products, sweet/fat processed	22	17	16	15	14	13	12	12	12	12	12	12
Salt/fat processed starch products	4	2	2	2	2	2	2	2	2	2	2	2
Potatoes and other tubers	79	90	90	92	96	101	101	101	102	104	105	105
Legumes	13	15	15	15	15	15	15	15	15	16	16	16
Poultry	30	95	98	102	93	78	62	47	31	15	0	0
Beef and calves	48	0	0	0	0	0	0	0	0	0	0	0
Pork and other meats	27	0	0	0	0	0	0	0	0	0	0	0
Offal	4	10	7	5	3	2	2	1	1	1	0	0
Processed meat	50	0	0	0	0	0	0	0	0	0	0	0
Oily fish	8	20	19	19	18	26	16	15	15	16	24	24
Other fish	22	10	10	11	11	7	17	16	16	16	7	7
Mollusks and crustaceans	5	5	6	7	9	14	20	28	28	28	28	28

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Diet composition, g/d	Males										
	Observed diet	Modeled diet with gradual meat reduction (%)									
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Eggs and egg-based dishes	14	17	17	18	19	21	22	23	24	25	28
Milk	84	100	102	105	110	130	128	123	125	129	134
Fresh natural dairy products	31	89	90	91	91	97	97	97	98	100	102
Fresh sweetened dairy products	50	0	0	0	0	0	0	0	0	0	0
Sweet milky desserts	19	19	20	19	18	18	18	19	19	20	21
Cheeses	49	36	35	35	34	34	34	33	33	34	34
Animal fats and assimilated fats	1	1	1	1	1	1	1	1	1	1	1
Butters and light butters	10	9	9	9	9	9	9	9	9	10	10
Vegetable fats rich in alpha-linoleic acid	0	22	22	22	23	23	23	23	24	22	22
Vegetable fats low in alpha-linoleic acid	12	0	0	0	0	0	0	0	0	2	3
Sauces and fresh creams	35	29	28	26	25	24	23	22	22	21	21
Sweet products or Sweet and fatty products	103	97	96	84	70	62	61	61	61	61	61
Drinking waters	1007	979	975	972	968	964	962	958	956	955	953
Sweetened soda type drinks	141	0	0	0	0	0	0	0	0	0	0
Fruit juices	80	78	50	35	27	22	20	18	17	15	14
Hot drinks	494	494	438	397	317	0	0	0	0	0	0
Salt	1	0	0	0	0	0	0	0	0	0	0
Condiments	4	2	2	2	1	1	1	1	1	1	1
Aromatic herbs, Spices except salt	2	2	2	2	2	2	2	2	2	2	2
Soups	71	0	0	0	0	0	0	0	0	0	0
Bouillons	5	0	0	0	0	0	0	0	0	0	0
Substitutes of animal products	3	4	4	4	3	4	4	4	4	4	4
Other foods	4	4	4	4	4	4	4	4	4	4	4
Alcoholic drinks	216	216	216	192	191	186	186	186	186	186	186

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SUPPLEMENTAL TABLE 7 cont. Absolute daily food group consumptions under modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

Diet composition, g/d	Females											
	Observed diet	Modeled diet with gradual meat reduction (%)										
		10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	
Vegetables	160	226	269	324	387	387	387	387	387	387	387	387
Fresh fruits	107	123	177	180	335	333	332	331	330	330	330	330
Dried fruits	1	53	53	22	24	26	28	28	29	29	29	29
Processed fruits: compotes and cooked fruits	15	0	0	102	0	0	0	0	0	0	0	0
Nuts, seeds and oleaginous fruits	2	3	3	3	3	3	3	3	3	3	3	3
Bread and refined bakery products	115	10	10	10	10	10	10	10	10	10	10	10
Complete and semi-complete bread and bakery products	15	118	118	120	119	122	124	128	133	139	146	
Other refined starches	72	0	0	0	0	0	0	0	0	0	0	0
Other complete and semi-complete starches	4	96	104	116	127	141	157	179	188	188	188	188
Starch-based products, sweet/fat processed	19	18	18	18	17	17	17	16	16	16	16	15
Salt/fat processed starch products	2	2	2	2	2	2	2	2	2	2	2	2
Potatoes and other tubers	49	58	60	62	62	62	62	62	63	63	63	63
Legumes	6	7	7	8	8	8	8	8	8	8	8	8
Poultry	31	62	69	67	58	48	38	28	18	8	0	0
Beef and calves	28	9	2	0	0	0	0	0	0	0	0	0
Pork and other meats	13	0	0	0	0	0	0	0	0	0	0	0
Offal	1	4	6	0	0	0	0	0	0	0	0	0
Processed meat	30	7	6	5	4	4	3	3	3	2	0	0
Oily fish	6	22	21	19	19	18	16	16	16	16	16	16
Other fish	15	10	14	20	20	21	21	21	21	20	20	20
Mollusks and crustaceans	4	6	8	11	14	19	25	26	26	26	26	26

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SUPPLEMENTAL TABLE 8. Standardized dual values showing the relative influences of the limiting constraints in modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

	Males									
	Modeled diet with gradual meat reduction (%) ¹									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Dual values of nutrient constraints ²										
Vitamin A	3.11	0.21	0.07	[0.001-0.01]	[0.001-0.01]	0.19	0.19	0.54	0.59	1.10
Vitamin C	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Bioavailable Iron	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Iodine	2.42	0.20	0.23	0.27	1.19	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Potassium	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Sodium	-8.01 ³	-1.39	-1.39	-1.46	-1.43	-1.48	-1.48	-0.77	-0.60	-0.97
Saturated fatty acids	-2.73	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Lauric + myristic + palmitic acids	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Linoleic acid	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	0.07	0.08	0.13
α -linolenic acid	4.03	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
EPA+DHA ⁴	[0.001-0.01]	0.02	0.01	0.01	[0.001-0.01]	0.03	0.03	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Sugar excluding lactose	-0.39	-0.03	-1.15	-1.98	-1.66	-0.04	-0.04	-0.05	-0.06	-0.17
Fiber	1.38	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]

¹ In each x% modeled scenario, total meat consumption is diminished by at least x% of its observed value.

² Standardized dual values representing the potential effect on the objective function of a 100% relaxation of the limiting bound of the constraint considered, in order to classify the nutritional constraints from the most to the least limiting (*i.e.*, active). Limiting constraints have a positive (negative) value if the lower (upper) bound is binding. Only nutrients with a limiting constraint (*i.e.* a non-null dual value) are presented here. Dual values are indicated as [0.001-0.01] when values are between 0.001 and 0.01.

³ For each step, the most limiting constraint (*i.e.*, with the highest absolute value) is in bold.

⁴ DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid.

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SUPPLEMENTAL TABLE 8 cont. Standardized dual values showing the relative influences of the limiting constraints in modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

	Females									
	Modeled diet with gradual meat reduction (%) ¹									
	10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Dual values of nutrient constraints ²										
Vitamin A	3.58	[0.001-0.01]	0.08	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Vitamin C	[0.001-0.01]	0.23	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Bioavailable iron	1.54	1.44	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Iodine	6.52	0.43	1.15	0.22	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Potassium	[0.001-0.01]	[0.001-0.01]	0.14	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Sodium	-8.02 ³	-1.73	-1.34	-1.49	-1.00	-0.93	-0.93	-0.85	-0.82	-0.75
Saturated fatty acids	-4.62	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Lauric + myristic + palmitic acids	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]
Linoleic acid	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	0.08
α -linolenic acid	3.97	0.01	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	0.05	0.05	0.03	[0.001-0.01]	[0.001-0.01]
EPA+DHA ⁴	[0.001-0.01]	0.05	0.05	0.04	0.02	0.02	0.02	0.02	0.02	0.02
Sugar excluding lactose	-1.54	-0.21	-0.15	-0.09	-0.10	-0.09	-0.09	-0.10	-0.10	-0.09
Fiber	4.06	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]	[0.001-0.01]

¹ In each x% modeled scenario, total meat consumption was diminished by at least x% of its observed value.

² Standardized dual values representing the potential effect on the objective function of a 100% relaxation of the limiting bound of the constraint considered, in order to classify the nutritional constraints from the most to the least limiting (*i.e.*, active). Limiting constraints have a positive (negative) value if the lower (upper) bound is binding. Only nutrients with a limiting constraint (*i.e.* with a non-null dual value) are presented here. Dual values are indicated as [0.001-0.01] when values are between 0.001 and 0.01.

³ For each step, the most limiting constraint (*i.e.*, with the highest absolute value) is in bold.

⁴ DHA, docosahexaenoic acid; EPA, eicosapentaenoic acid.

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SUPPLEMENTAL TABLE 9. Protein and amino acid intakes (mg·(kg_bw·d)⁻¹) in observed and modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, *n*=564 males and *n*=561 females) ¹

Nutrients	EAR ²	97.5% intake (EAR + 2 SD)	Males										
			Observed diet	Modeled diet with gradual meat reduction (%) ³									
				10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Aspartic acid + asparagine	-	-	117	106	108	111	111	109	106	103	99	95	91
Alanine	-	-	65	56	56	57	56	55	53	51	49	46	43
Arginine	-	-	73	65	66	68	66	65	63	61	59	56	53
Methionine + Cysteine	15	19	53	43	43	44	43	42	41	41	39	37	36
<i>Methionine</i>	-	-	34	27	27	27	27	26	25	25	23	22	21
<i>Cysteine</i>	-	-	19	16	16	17	16	16	16	16	16	15	15
Glutamic acid + glutamine	-	-	275	241	244	248	246	244	243	241	238	232	226
Glycine	-	-	54	47	48	48	47	46	45	44	42	40	38
Histidine	10	12	39	32	32	33	32	32	31	30	28	27	26
Isoleucine	20	25	59	51	52	53	52	51	49	48	46	44	42
Leucine	39	48	106	91	92	94	92	90	88	85	82	79	75
Lysine	30	37	89	79	80	82	80	77	74	70	66	61	57
Phenylalanine + Tyrosine	25	31	106	92	93	95	93	91	90	88	85	82	79
<i>Phenylalanine</i>	-	-	60	52	53	54	53	52	51	51	49	48	46
<i>Tyrosine</i>	-	-	46	40	40	41	40	39	38	37	36	34	33
Proline	-	-	94	84	84	85	84	84	84	84	84	82	81
Serine	-	-	61	55	56	56	56	55	55	54	53	51	50
Threonine	15	19	54	46	47	47	46	45	44	43	41	39	37
Tryptophan	4	5	16	14	15	15	15	14	14	14	14	13	13
Valine	26	32	69	60	61	62	61	60	58	57	55	53	51
Protein	660	818	1 354	1 185	1 201	1 221	1 205	1 185	1 164	1 141	1 107	1 066	1 023

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¹ Intakes ($\text{mg}\cdot\text{d}^{-1}$) were converted to $\text{mg}\cdot\text{kg}^{-1}$ body weight/day for a mean body weight of 77.4 kg for males. To account for the slightly lower average digestibility of plant protein, protein intake from plants was reduced by 5% when calculating total protein and amino acid intakes, as previously described in the Methods section (L122-L123). INCA3, Individual and National Consumption Survey 3 ($n = 1\ 125$).

² EAR, Estimated average requirement. Estimated average requirement of adults for protein and indispensable amino acids, based on the Joint FAO/WHO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition (2002) (5).

³ In each x% modeled scenario, total meat consumption was reduced by at least x% of its observed value.

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SUPPLEMENTAL TABLE 9 cont. Protein and amino acid intakes (mg·(kg_bw-d)⁻¹) in observed and modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, *n*=564 males and *n*=561 females) ¹

Nutrients	EAR ²	97.5% intake (EAR + 2 SD)	Females										
			Observed diet	Modeled diet with gradual meat reduction (%) ³									
				10%	20%	30%	40%	50%	60%	70%	80%	90%	100%
Aspartic acid + asparagine	-	-	101	112	115	114	115	113	112	109	106	102	99
Alanine	-	-	55	58	60	59	59	57	57	55	53	51	49
Arginine	-	-	63	69	71	69	69	68	68	66	64	61	59
Methionine + Cysteine	15	19	45	47	47	47	46	46	46	45	44	43	42
<i>Methionine</i>	-	-	28	29	29	29	29	28	28	27	26	25	24
<i>Cysteine</i>	-	-	17	18	18	18	18	18	18	18	18	18	17
Glutamic acid + glutamine	-	-	240	259	264	265	267	266	266	266	264	260	258
Glycine	-	-	46	50	51	50	49	49	48	47	46	44	43
Histidine	10	12	33	34	34	34	34	33	33	32	31	30	28
Isoleucine	20	25	51	54	56	55	55	54	54	52	51	49	48
Leucine	39	48	91	97	99	99	98	96	95	93	91	88	85
Lysine	30	37	77	82	84	84	83	80	78	75	71	68	65
Phenylalanine + Tyrosine	25	31	92	98	100	99	99	98	97	95	93	91	88
<i>Phenylalanine</i>	-	-	52	56	57	56	57	56	56	55	54	53	52
<i>Tyrosine</i>	-	-	40	42	43	43	42	42	41	40	39	37	36
Proline	-	-	82	90	91	91	92	92	93	93	93	92	91
Serine	-	-	54	59	60	60	61	60	60	60	59	57	57
Threonine	15	19	46	49	50	49	49	48	48	46	45	43	42
Tryptophan	4	5	14	15	16	16	16	16	16	15	15	15	14
Valine	26	32	60	64	66	65	65	64	64	63	61	60	58
Protein	660	818	1 169	1 250	1 277	1 265	1 262	1 243	1 227	1 206	1 179	1 148	1 122

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¹ Intakes ($\text{mg}\cdot\text{d}^{-1}$) were converted to $\text{mg}\cdot\text{kg}^{-1}$ body weight/day for a mean body weight of 66.0 kg for females. To account for the slightly lower average digestibility of plant protein, protein intake from plants was reduced by 5% when calculating total protein and amino acid intakes, as previously described in the Methods section (L122-L123). INCA3, Individual and National Consumption Survey 3 ($n = 1125$).

² EAR, Estimated average requirement. Estimated average requirement of adults for protein and indispensable amino acids, based on the Joint FAO/WHO/UNU Expert Consultation on Protein and Amino Acid Requirements in Human Nutrition (2002) (5).

³ In each x% modeled scenario, total meat consumption was reduced by at least x% of its observed value

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SUPPLEMENTAL TABLE 10. Iron intakes, iron bioavailability, bioavailable iron, zinc intakes, zinc bioavailability and bioavailable zinc in observed and modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males and females (INCA3 survey, $n=564$ males and $n=561$ females)

		Men											
Nutrient	Unit	Observed diet	Modeled diets ¹										
			10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	
Iron	mg·d ⁻¹	13	13	13	13	13	13	13	13	13	13	13	13
Bioavailable Iron	mg·d ⁻¹	1.68	1.20	1.21	1.20	1.20	1.31	1.31	1.31	1.29	1.26	1.23	
Iron bioavailability	%	13%	9%	9%	9%	9%	10%	10%	10%	10%	9%	9%	
Zinc	mg·d ⁻¹	12	10	10	10	10	10	10	11	11	11	11	
Bioavailable zinc	mg·d ⁻¹	3.6	2.9	2.9	2.9	2.8	2.8	2.8	2.8	2.8	2.8	2.7	
Zinc bioavailability	%	30%	30%	30%	29%	28%	28%	27%	26%	26%	26%	26%	

		Women											
Nutrient	Unit	Observed diet	Modeled diets ¹										
			10%	20%	30%	40%	50%	60%	70%	80%	90%	100%	
Iron	mg·d ⁻¹	10	12	12	11	12	12	12	12	13	13	13	
Bioavailable Iron	mg·d ⁻¹	1.21	1.16	1.16	1.17	1.22	1.22	1.22	1.21	1.20	1.19	1.17	
Iron bioavailability	%	12%	10%	10%	10%	10%	10%	10%	10%	10%	9%	9%	
Zinc	mg·d ⁻¹	9	9	9	9	9	10	10	10	10	10	10	
Bioavailable zinc	mg·d ⁻¹	3.2	2.9	2.8	2.8	2.8	2.8	2.9	2.8	2.8	2.8	2.8	
Zinc bioavailability	%	36%	31%	31%	30%	29%	29%	28%	27%	27%	27%	27%	

¹ In each x% modeled scenario, total meat consumption was diminished by at least x% of its observed value.

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SUPPLEMENTAL METHOD 1 French amino acid database

An amino acid (AA) database was developed for the 1761 food items in the full repertoire of adults in the INCA3 study, using both the method described here and the database developed by de Gavelle et al. (6).

Sources of AA content

The AA contents of different food items were collected from published French sources (7) and international databases (8). These data came from analytical data on AA obtained using automated AA analyzers (involving ion-exchange chromatography) or high-performance liquid chromatography (HPLC).

Assignment to INCA3 food items

To assign the AA contents of the foods analyzed to INCA3 food items, we used a step procedure as follows:

Step 1: Direct analytical data from French published sources

Very few analyses had been performed on French foods using chromatographic methods to analyze 18 AAs. Data from a study on the nutritional value of meat by the *Centre d'Information des Viandes* were used for most of the beef, veal, lamb, horse meat and offal food items (7).

Step 2: Data based on "similar" food items

When no direct analytical data corresponded to INCA3 food items, assignments were made using "similar" food items. Firstly, if data were available on a different form of the same food (*e.g.* cooked and not raw), we hypothesized that the AA profiles of the proteins were not modified by the cooking processes and the data for the different form of the same food were assigned to the INCA3 food items. Then, if data were unavailable for a food item but existed for similar species (*e.g.* food from different cuts of the same animal), we assigned the similar food to the INCA3 food item. In order to compare AA profiles between different foods, we conducted our analyses in mg per gram of total nitrogen ($\text{mg}\cdot\text{g}^{-1} \text{N}_{\text{tot}}$).

Step 3: Use of recipes to break down mixed food items

Mixed INCA3 food items for which no data were found (*e.g.* chili con carne or lasagna) were broken down into ingredients using the INCA3 recipe table, and the food item AA content was calculated as a combination of the AA contents of its ingredients.

Step 4: Assignment to 0 for foods containing very little or no protein

The AA content of some INCA3 food items was assigned to 0 as these foods contained very low or no protein levels (*e.g.* oil or alcoholic beverages).

Calculation of the AA contents of foods

AA profile data formatting

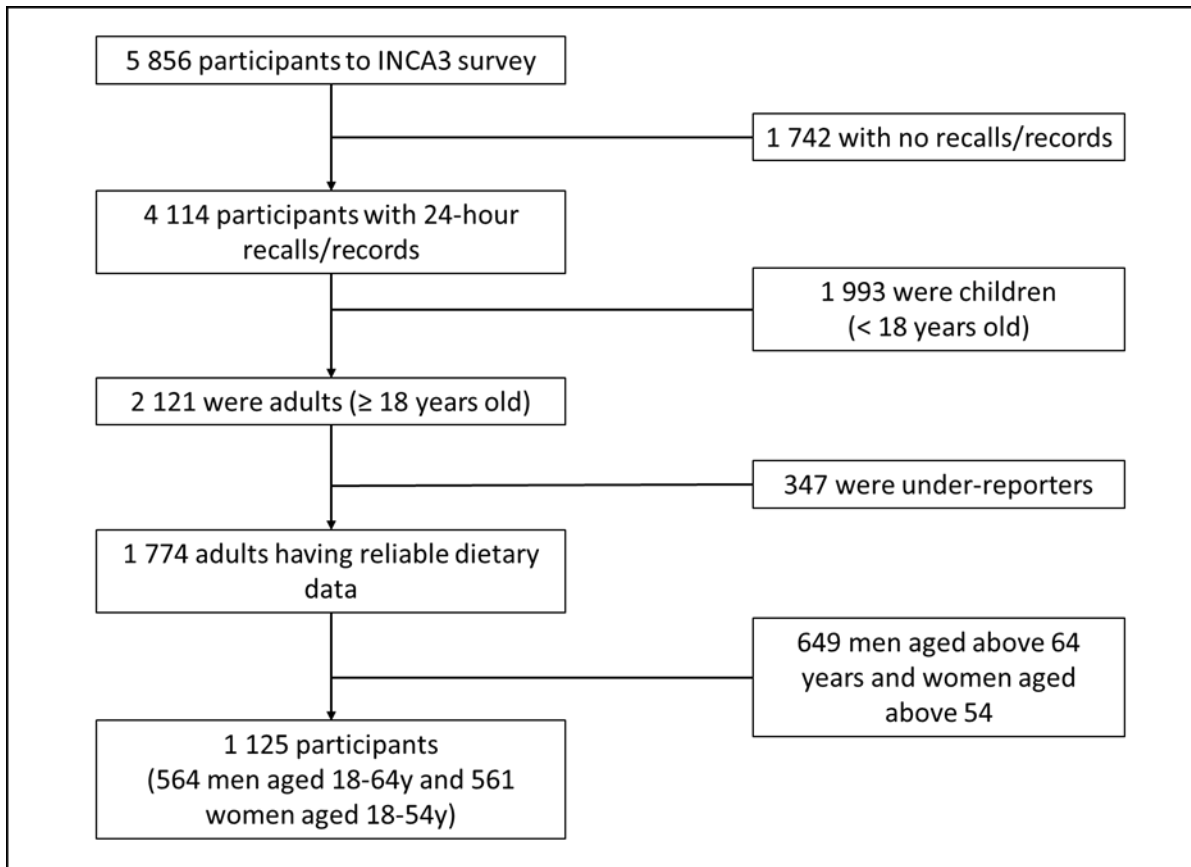
We used the 2016 nutritional composition database from the French *Centre d'Information sur la Qualité des Aliments; CIQUAL* (9) for protein content, which we multiplied by the AA contents (in $\text{mg}\cdot\text{g}^{-1} \text{N}_{\text{tot}}$) of the databases from which the data were borrowed. The CIQUAL table expresses protein content in grams per 100 grams of food. For database matching, a conversion was therefore necessary and was carried out using the following formula:

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$$\text{AA (mg/100g of food)} = \frac{\text{AA (mg/g Ntot)} * \text{protein (g/100g of food)}}{\text{Jones' Factor}}$$

The Jones factor used is from the USDA database (8).

SUPPLEMENTAL FIGURE 1 Flow chart explaining the sampling of French participants from the third Individual and National Study on Food Consumption Survey (INCA3) for the present study



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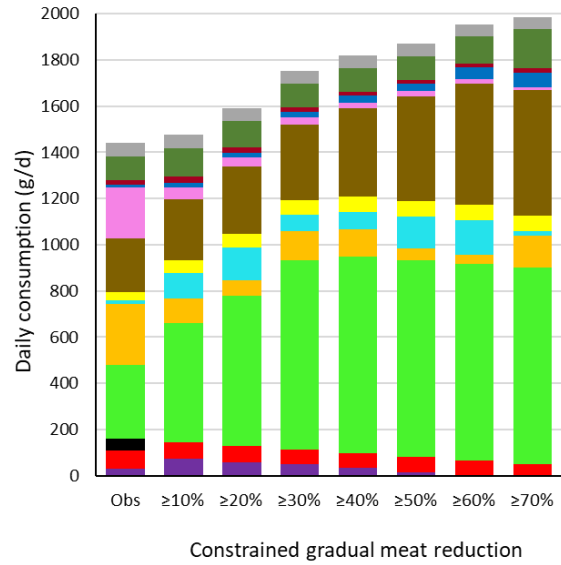
SUPPLEMENTAL FIGURE 2. Average daily consumption of food groups in observed (Obs) and modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males (panel A) and females (panel B) (INCA3 survey, $n=564$ males and $n=561$ females), without flexibility on bioavailable iron and zinc.

Here, the constraints on bioavailable iron and zinc were set at the current reference values and no flexibility on those reference values was introduced. Modeled diets could be identified up to the 70% step of the meat reduction transition, whatever the sex. Beyond this step, modeled diets could no longer be identified. Under this alternative option, the reference values for bioavailable iron and zinc were set at the current reference values (*i.e.* 1.72 mg/d for both sexes for bioavailable iron, 3.63 g/d in males and 3.23 g/d in females for bioavailable zinc).

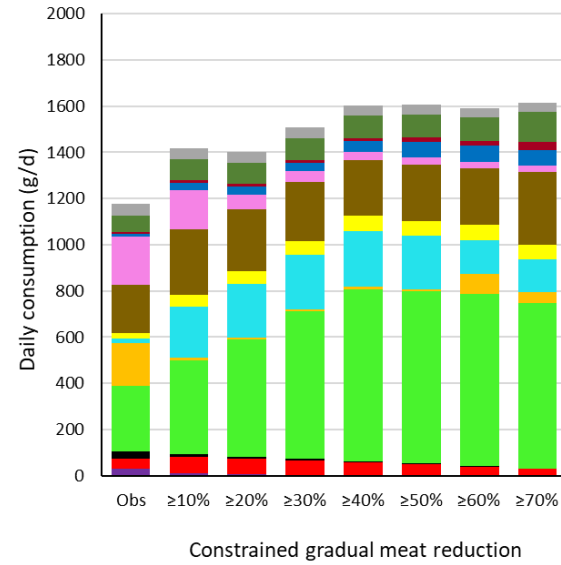
In each x% modeled scenario, total meat consumption was diminished by at least x% of its observed value. For clarity, the 45 modeled food groups are not shown here but were grouped into broader categories included in the *Healthy Dietary Pattern* criterion (such as red meat, processed meat, soft drinks, grain products, fruit and vegetables) or represented other protein sources (such as poultry, seafood, dairy products, eggs, legumes and nuts). The remaining food groups were grouped as "others" (8 groups) and "other drinks" (3 groups) and are not presented in Supplemental Figure 2. Detailed food categories are presented in Supplemental Table 2.

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A. Males



B. Females



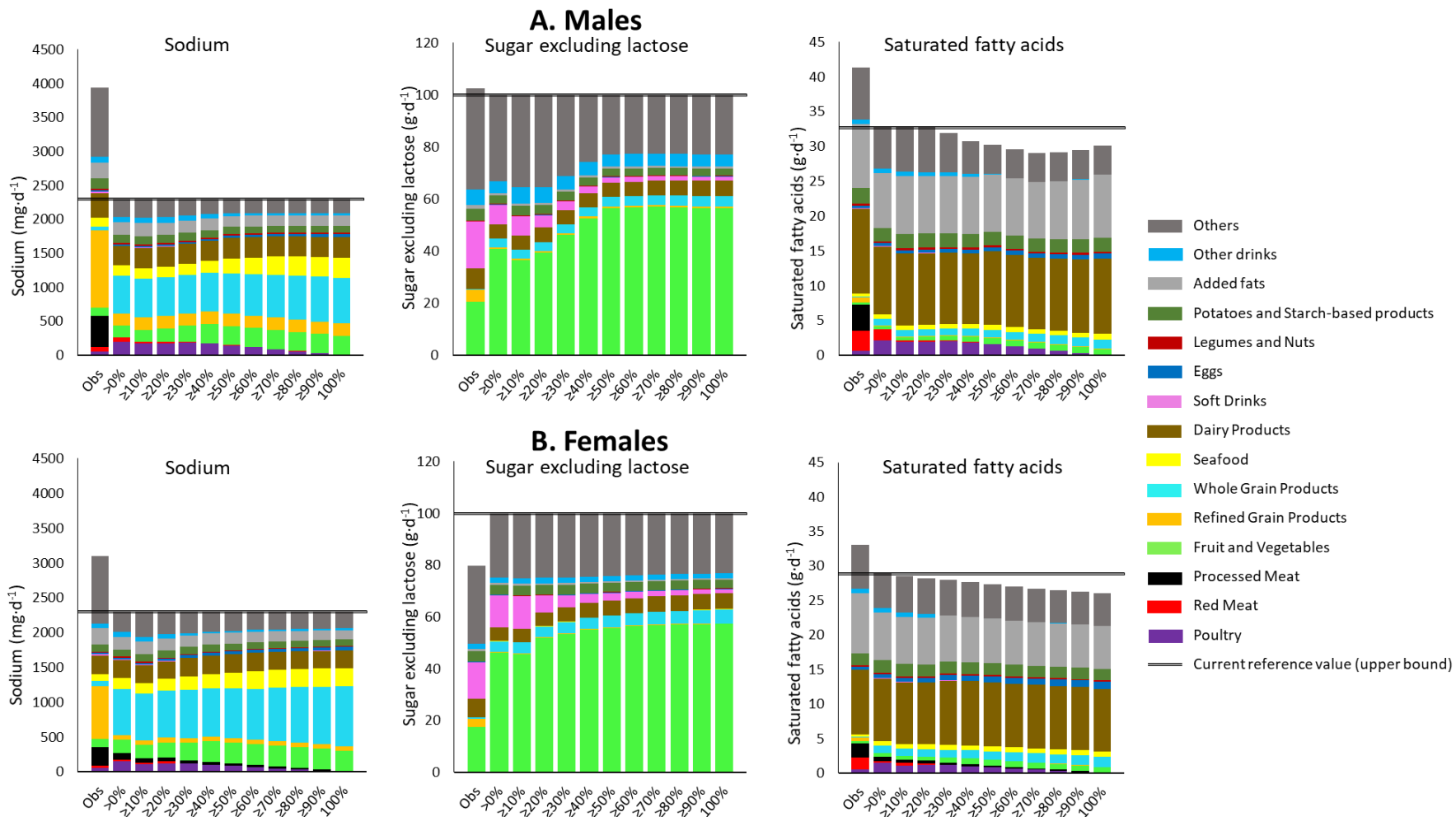
- Added fats
- Potatoes and Starch-based products
- Legumes and Nuts
- Eggs
- Soft Drinks
- Dairy Products
- Seafood
- Whole Grain Products
- Refined Grain Products
- Fruit and Vegetables
- Processed Meat
- Red Meat
- Poultry

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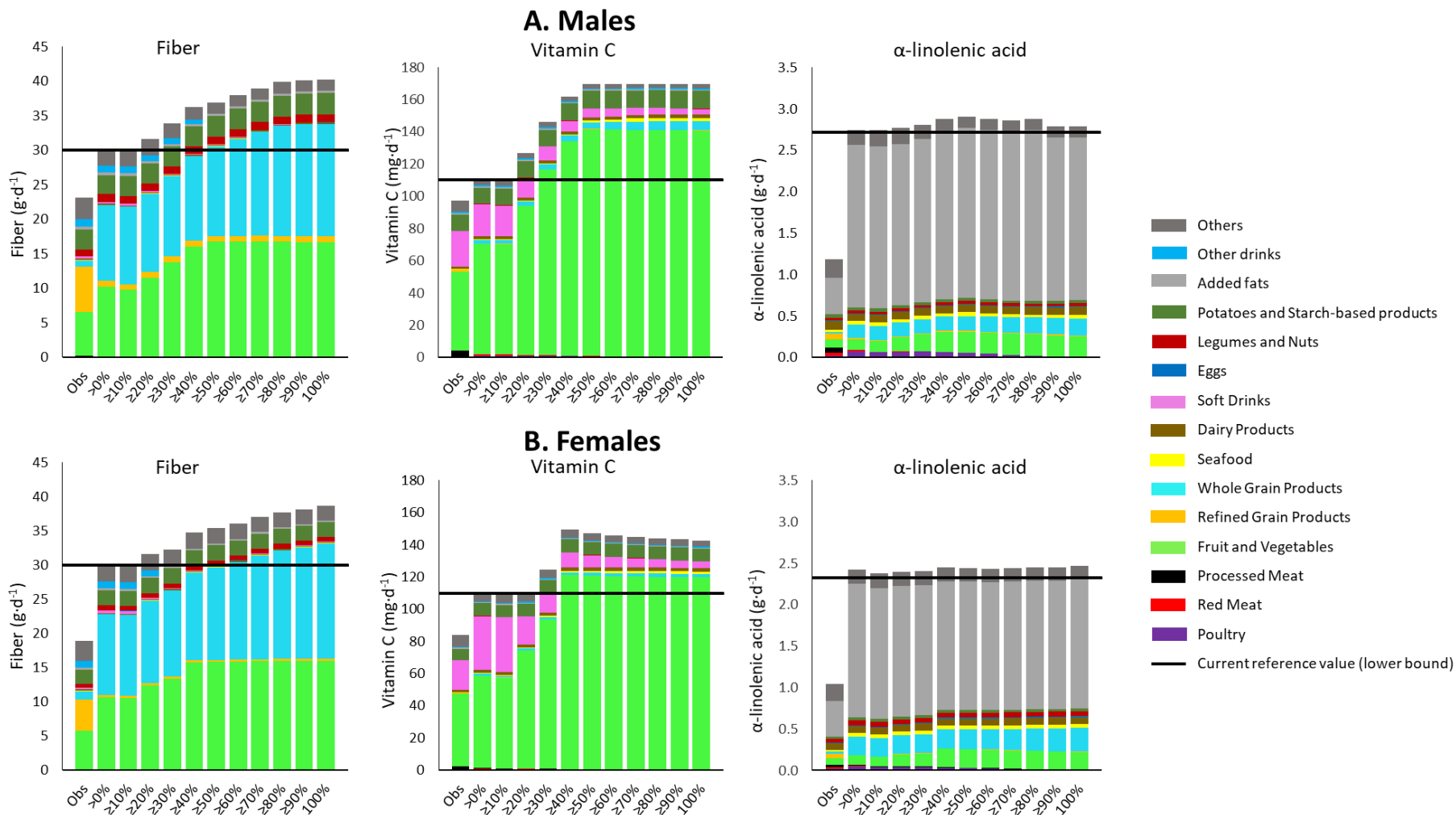
SUPPLEMENTAL FIGURE 3. Contribution of food groups to sodium, sugars excluding lactose, saturated fatty acids, fiber, vitamin C, α -linolenic acid, iodine, vitamin B6 and selenium in observed (Obs) and modeled diets as optimized to be healthier while taking account of dietary inertia during a sequential transition towards diets containing less meat, according to gradual constraints for meat reduction (from at least 10% to 100%) in males (panel A) and females (panel B) (INCA3 survey, $n=564$ males and $n=561$ females)

In each x% modeled scenario, total meat consumption was diminished by at least x% of its observed value. For clarity, the 45 modeled food groups are not shown here but were grouped into broader categories included in the *Healthy Dietary Pattern* criterion (such as red meat, processed meat, soft drinks, grain products, fruits and vegetables) or that represented other protein sources (such as poultry, seafood, dairy products, eggs, legumes and nuts), and the remaining food groups were grouped as "others" (8 groups) and "other drinks" (3 groups). Detailed food categories are presented in Supplemental Table 2. For each nutrient, current reference values are represented by horizontal lines.

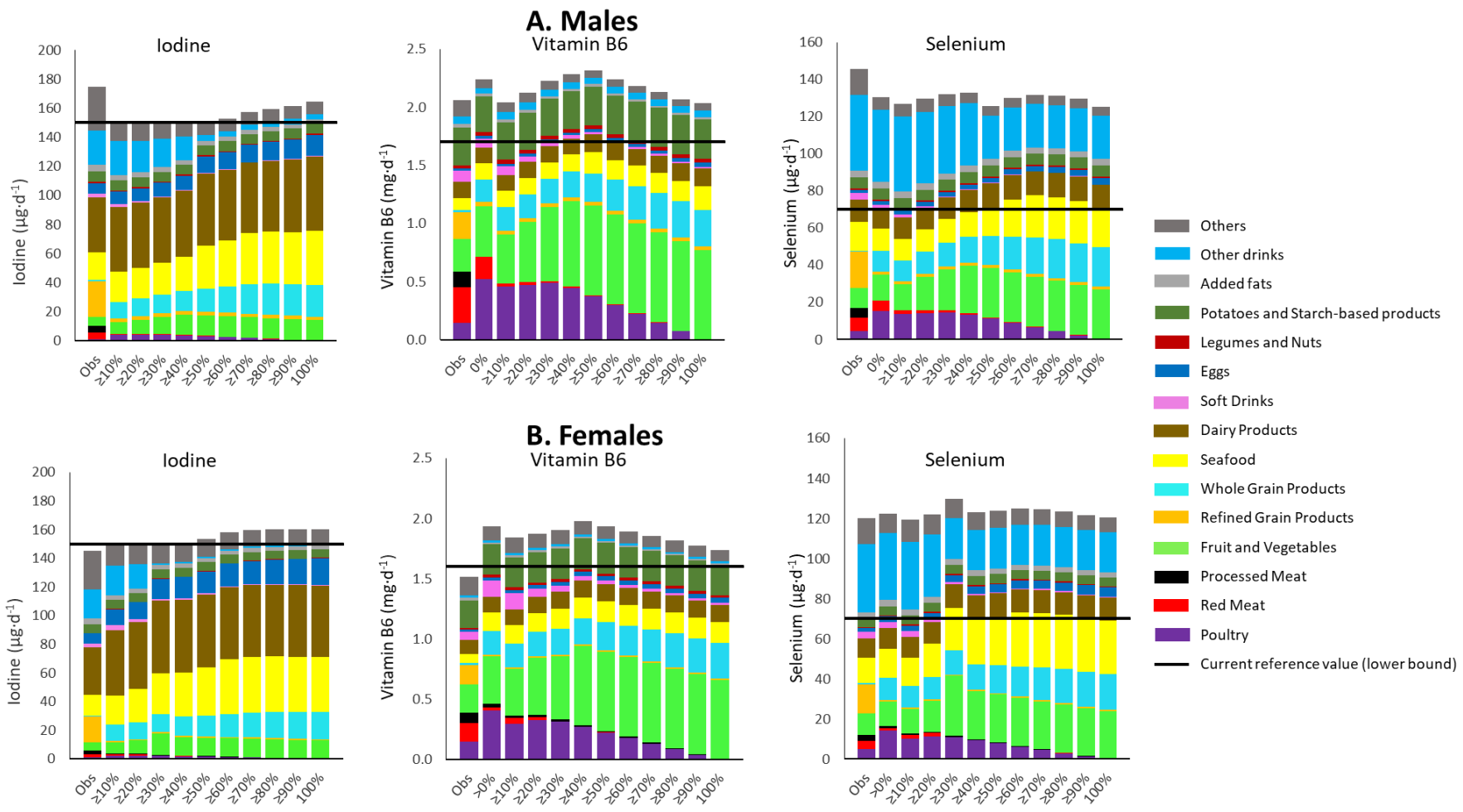
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