

Supplementary Information

The revised Healthy Purchase Index (r-HPI): a validated tool for exploring the nutritional quality of household food purchases

European Journal of Nutrition

Marlène Perignon¹, Pascaline Rollet¹, Marion Tharrey¹, Daisy Recchia¹, Sophie Drogué¹, France Caillavet², Caroline Mejean¹, Nicole Darmon¹

¹ MoISA, Univ Montpellier, CIHEAM-IAMM, CIRAD, INRAE, Institut Agro, IRD, Montpellier, France

² ALISS, INRAE, Univ Paris-Saclay, Ivry, France

Corresponding author: Marlène Perignon, marlene.perignon@inrae.fr

Supplemental Table S1: Food groups and subgroups classification of food items purchased by households from the Kantar Worldpanel 2014

Groups	Subgroups	Examples of food items included
Fruits & Vegetables	Vegetables	Fresh vegetables, vegetable soup, canned vegetables
	Fruits	Fresh fruit, canned fruit, stewed fruit
	Dried fruits & nuts	Unsalted dried fruit, nuts, seeds
Meat, fish, eggs	Red meat	Beef, pork, lamb,
	Processed meat	Cured and cooked ham, sausages, bacon, pâté
	Eggs & poultry	Hard-boiled egg, fried egg, omelette, chicken, duck, turkey
	Fish	Fresh fish, canned fish, shellfish, surimi
Starches	Unrefined starches	Potatoes, legumes, wholegrain products
	Refined grains	Bread rolls, fresh bread, pasta, rice, flour
Dairy products	Milk & yoghurt	Refrigerated and long-life milk, plain yoghurt, sweetened yoghurt, fruit yoghurt, yoghurt drink
	Cheese	Hard cheese, soft cheese, cream cheese
Mixed dishes	Ready meals	(frozen) ready meals, canned meals, salads
	Savoury dishes	Quiche, pizza, savoury pies, puff pastries, burgers, sandwiches
Added fats	Vegetable fats	Vegetable oil, margarine, salad dressing
	Animal fats	Cream, butter
Discretionary foods	Savoury snacks	crackers, chips, salted and roasted nuts, olives
	Sugar sweetened beverages	Soda, nectars
	Calorie free beverages	Diet soft drinks
	Fruit juices	Fresh fruit juice, concentrated fruit juice
	Sugared cereals	Breakfast cereals
	Dairy desserts	Cream dessert, ice cream
	Sweet snacks	Cakes, biscuits, pastries, candies, chocolate
Sauces	Ketchup, sauces including soya/tomato/barbecue, etc.	
Alcoholic beverages	Alcoholic beverages	Beer, wine, liquor, whiskey
Condiments	Spices	Salt, pepper, herbs, spices, mustard, pickles
Waters and hot beverages	Waters and hot beverages	Mineral water, sparkling water, tea, coffee
Baby foods	Baby foods	Infant formulas, baby food jars

Supplemental Table S2: Socio-economic and food purchases characteristics in the adaptation sample (n=4,375 households) and the external validation sample (n=2,188 households)

	Adaptation sample (n=4375)		External validation sample (n=2188)		p- value ²
	Mean ¹	SD	Mean ¹	SD	
Age of the respondent (y)	52.6	15.3	53.1	15.4	0.17
Number of household members	2.475	1.35	2.441	1.39	0.15
Income per consumption unit (€/month)	1748.5	809.3	1711.7	786.4	0.07
Household structure					0.10
1 adult	30.49%		32.13%		
1 adult with child(ren)	1.87%		1.14%		
Several adults	41.1%		40.49%		
Several adults with child(ren)	26.54%		26.23%		
Level of education of the respondent					0.75
Primary and secondary school	13.04%		13.88%		
High school	48.98%		48.96%		
Higher secondary school	19.8%		19.01%		
Bachelor or Master degree or higher	18.18%		18.14%		
Socio-professional category of the respondent					0.85
Farmers	0.25%		0.23%		
Artisans. shopkeepers. entrepreneurs	1.46%		1.14%		
Executives and intellectual professionals	6.67%		6.35%		
Intermediate professions	15.45%		14.44%		
Employees	34.35%		34.6%		
Workers	4.37%		4.25%		
Retired	28.11%		29.34%		
Unemployed	9.33%		9.64%		
Residence area					0.76
Paris region	18.1%		18.37%		
Greater Paris Area	18.51%		18.83%		
North	7.34%		6.54%		
East	9.67%		9.73%		
West	15.41%		16.73%		
South-West	10.72%		10.42%		
Central East	10.49%		10.42%		
Mediterranean area	9.76%		8.96%		
Food expenditure (€/4 weeks)	298.7	160.9	292.7	157.6	0.13
Food expenditure per person (€/4 weeks)	142.2	84.1	142.2	80.8	0.88

¹or % where specified, ²Wilcoxon tests (for age, number of household members, income, food expenditure) or Chi² tests (for household structure, level of education, socio-professional category, residence area) between adaptation and external validation samples characteristics

Supplemental Table 3: definition of cut-off values for point allocation

Subscore component	Definition of cut-off values
Fruits & Vegetables	The segmented regression between the MAR and the “Fruits & Vegetables” expenditure share showed two breakpoints at 6% and 23% of expenditure. The regression slope between these two breakpoints being steep and a high proportion of households belonging to this segment, deciles of expenditure share were used to define intermediate cut-offs at 9% (3 rd decile), 12% (median) and 16% (7 th decile). The regression slope above 23% of expenditure being approximately null, attribution of additional point above this cut-off was not relevant. The “Fruits & Vegetables” component thus scored from 0 to 4 points across 4 cut-offs (6%, 9%, 12%, 16%) as described in Table 1 .
Cheese	The segmented regression between the MAR and the “Cheese” subgroup expenditure share showed a breakpoint at 4% of expenditure. Moreover, higher values of MER being observed for expenditure share above 5%, deciles were used to define an additional cut-off at 8% (7 th decile) above which the MAR was lower and the MER was higher. The “Cheese” component thus scored from -1 to 1 across 2 cut-offs (4% and 8%) as described in Table 1 .
Milk & Yogurt	The segmented regression between the MAR and the “Milk & Yogurt” subgroup expenditure share showed 2 breakpoints at 2% and 9% of expenditure, with a positive slope between 0-2%, a stabilization between 2-9%, and a negative slope above 9%. Moreover, the segmented regression between the MER and the “Milk & Yogurt” subgroup expenditure share identified a breakpoint at 2% of expenditure, with positive slopes between 0-2% and above 2%, indicating a lower nutritional quality for an expenditure share above 9% (hence a lower number of point) than below 2%. The “Milk & Yogurt” component thus scored 1 point for an expenditure share between 2-9%, 0.5 point when <2% and 0 point when >9%.
Egg & Poultry	The segmented regression between the MAR and the “Egg & Poultry” subgroup expenditure share showed a breakpoint at 3%. This component thus scored 1 point for an expenditure share above 3%, and 0 point when <3%.
Fish	The segmented regression between the MAR and the “Fish” subgroup expenditure share showed 2 breakpoints at 1.5% and 9%. The slope between these two breakpoints being steep and a high proportion of households belonging to this segment, deciles of expenditure share were used to define intermediate cut-offs at 4% (median). In addition, the fish consumption guidelines being limited to 2 times / week due to a risk of exposure to food contaminants, the maximum cut-off was lowered from 9% to 7% (7 th decile) to avoid encouraging a too high consumption. The “Fish” component thus scored from 0 to 2 points across 3 cut-offs (1.5%, 4% and 7%) as described in Table 1 .
Discretionary foods	The segmented regressions between the “Discretionary foods” group expenditure share and the MAR and the MER both showed a breakpoint at 13% of expenditure. The MER regression slopes being steep between 0-13% and 13-21%, and a high proportion of households belonging to these segments, deciles of expenditure share were used to define intermediate cut-offs at 7% (1 st decile) and 18% (median). The “Discretionary foods” component thus scored from 0 to -3 points across 3 cut-offs (7%, 13% and 18%) as described in Table 1 .
Unrefined starches	The segmented regressions between the MAR and the “Unrefined starches” subgroup expenditure share within starches group showed breakpoints at 30% of expenditure. The regression slope being steep between 0-30% and a high proportion of households belonging to this segment (60% of the sample has an expenditure share <32%), deciles of expenditure share were used to define an

	intermediate cut-off at 18% (4th decile). The “Unrefined starches” component thus scored from 0 to 2 points across 4 classes as described in Table 1 .
Red meat	The segmented regression between the MAR and the “Red meat” subgroup expenditure share showed a breakpoint at 21% of expenditure, with an inversion of slope that became negative – hence an impairment of nutritional quality – for expenditure share >21%. Considering that guidelines are to limit red meat consumption, this component scored from 0 to -1 points across 2 classes as described in Table 1 .
Processed meat	The segmented regression between the MER and the “Processed meat” subgroup expenditure share showed a breakpoint at 6% of expenditure. Deciles were used to add an additional cut-off at 10% (7 th decile). This component thus scored from 0 to -2 points across 3 classes as described in Table 1 .
Fats	For the “Fats” group, households with no purchase of fats had a lower MAR and a higher MER than households purchasing fats but 0% of animal fats, hence 0 point was attributed in the first case and 1 point for the second. MAR decreased and MER increased with higher expenditure share of animal fats: deciles of expenditure share were used to define additional cut-offs at 1% (3 rd decile=0.8%) and 2% (6 th decile=1.9%). The “animal fats” component thus scored from -1 to 1 point as described in Table 1 .

MAR: Mean Adequacy Ratio; MER: Mean Excess Ratio

Supplemental Table S4: Correlations between the revised Healthy Purchase Index (r-HPI) components, total score and energy content of food purchases, in the adaptation sample (panel A, n=4,375) and the external validation sample (panel B, n=2,188) of French households from the Kantar Worldpanel

(A)

		Fruits	Vegetables	Starches	Dairy	MFE	FV	Cheese	Milk & Yogurts	Eggs & Poultry	Fish	Red meat	Processed meat	Fats	Unrefined starch	Discretionary foods	r-HPI	Energy	
Diversity subscore	Fruits	1.000																	
	Vegetables	0.224 ***	1.000																
	Starches	0.013	0.083 ***	1.000															
	Dairy	0.021	0.031 *	0.097 ***	1.000														
	MFE	0.030 *	0.072 ***	0.005	-0.052 ***	1.000													
Quality subscore	FV	0.598 ***	0.533 ***	0.039 *	-0.003	0.017	1.000												
	Cheese	0.021	-0.006	-0.073 ***	-0.525 ***	0.020	0.034 *	1.000											
	Milk & Yogurts	0.042 **	0.036 *	0.016	0.019	0.105 ***	0.017	-0.055 ***	1.000										
	Eggs & Poultry	0.017	0.043 **	0.084 ***	-0.008	0.342 ***	-0.005	-0.003	0.077 ***	1.000									
	Fish	0.119 ***	0.101 ***	-0.046 **	-0.068 ***	0.300 ***	0.133 ***	0.058 ***	0.052 ***	0.027	1.000								
	Red meat	-0.004	-0.030 *	0.067 ***	0.099 ***	-0.164 ***	0.018	-0.086 ***	-0.031 *	0.006	0.019	1.000							
	Processed meat	0.078 ***	0.059 ***	-0.028	-0.041 **	-0.301 ***	0.122 ***	0.086 ***	-0.013	-0.052 ***	0.088 ***	-0.020	1.000						
	Fats	0.026	0.012	-0.066 ***	-0.090 ***	-0.016	0.029	0.081 ***	0.009	-0.043 **	0.041 **	-0.016	0.080 ***	1.000					
	Unrefined starch	0.078 ***	0.156 ***	0.182 ***	-0.004	0.097 ***	0.142 ***	-0.015	0.061 ***	0.058 ***	0.021	-0.043 **	0.013	0.062 ***	1.000				
	Discretionary foods	0.137 ***	0.140 ***	-0.102 ***	-0.095 ***	0.201 ***	0.242 ***	0.002	-0.004	0.064 ***	0.201 ***	-0.200 ***	-0.034 *	0.020	0.107 ***	1.000			
Total score	r-HPI	0.518 ***	0.508 ***	0.150 ***	-0.051 ***	0.246 ***	0.722 ***	0.192 ***	0.151 ***	0.211 ***	0.417 ***	-0.016	0.282 ***	0.272 ***	0.395 ***	0.465 ***	1.000		
	Energy	-0.092 ***	-0.017	0.201 ***	0.098 ***	0.157 ***	-0.223 ***	-0.071 ***	0.147 ***	0.175 ***	-0.019	0.009	-0.079 ***	-0.065 ***	0.077 ***	-0.222 ***	-0.096 ***	1.000	

* p<0.05; **p<0.01; ***p<0.001 ; FV : Fruits and Vegetables, MFE: Meat/Fish/eggs; r-HPI: revised Healthy Purchase Index

(B)

	Fruits	Vegetables	Starches	Dairy	MFE	FV	Cheese	Milk & Yogurts	Eggs & Poultry	Fish	Red meat	Processed meat	Fats	Unrefined starch	Discretionary foods	r-HPI	Energy
Diversity subscore	Fruits	1.000															
	Vegetables	0.226 ***	1.000														
	Starches	0.001	0.090 ***	1.000													
	Dairy	0.040	0.034	0.120 ***	1.000												
	MFE	0.031	0.074 ***	0.008	-0.048 *	1.000											
Quality subscore	FV	0.601 ***	0.580 ***	0.013	0.030	-0.007	1.000										
	Cheese	-0.009	0.008	-0.076 ***	-0.529 ***	0.006	0.013	1.000									
	Milk & Yogurts	0.042 *	0.043 *	0.024	-0.003	0.131 ***	0.047 *	-0.034	1.000								
	Eggs & Poultry	0.020	0.077 ***	0.053 *	0.035	0.280 ***	0.022	-0.004	0.072 ***	1.000							
	Fish	0.124 ***	0.109 ***	-0.025	-0.106 ***	0.304 ***	0.124 ***	0.071 ***	0.045 *	-0.007	1.000						
	Red meat	0.014	-0.010	0.019	0.082 ***	-0.160 ***	0.004	-0.075 ***	-0.019	0.008	-0.002	1.000					
	Processed meat	0.045 *	0.056 **	-0.017	-0.031	-0.330 ***	0.133 ***	0.089 ***	-0.069 **	-0.046 *	0.055 **	-0.009	1.000				
	Fats	-0.018	-0.001	-0.092 ***	-0.082 ***	-0.030	0.013	0.079 ***	0.042	-0.024	0.045 *	0.010	0.067 **	1.000			
	Unrefined starch	0.023	0.148 ***	0.167 ***	-0.042 *	0.077 ***	0.108 ***	0.034	0.073 ***	0.038	0.004	-0.041	0.003	0.014	1.000		
	Discretionary foods	0.140 ***	0.178 ***	-0.090 ***	-0.090 ***	0.200 ***	0.270 ***	0.009	0.002	0.013	0.176 ***	-0.171 ***	-0.065 **	0.013	0.134 ***	1.000	
Total score	r-HPI	0.491 ***	0.563 ***	0.146 ***	-0.039	0.216 ***	0.743 ***	0.197 ***	0.164 ***	0.197 ***	0.392 ***	-0.018	0.262 ***	0.249 ***	0.368 ***	0.470 ***	1.000
	Energy	-0.054 *	-0.054 *	0.203 ***	0.098 ***	0.084 ***	-0.213 ***	-0.090 ***	0.086 ***	0.173 ***	-0.007	0.056 **	-0.076 ***	-0.071 ***	0.060 **	-0.256 ***	0.124 ***

* p< 0.05; **p< 0.01; ***p< 0.001 ; FV : Fruits and Vegetables, MFE: Meat/Fish/eggs; r-HPI: revised Healthy Purchase Index

Supplemental Table S5: Correlations between the four nutritional quality indicators (NRF 9.3, MAR, MER, SED), excess ratios of nutrient included in the MER (SFA, free sugars, sodium) and the previous (HPI) and revised (r-HPI) version of the HPI in the external validation sample of 2,188 households from the French Kantar WorldPanel.

	HPI		r-HPI	
	(previous version)		(revised version)	
NRF 9.3	0,62	***	0.60	***
MAR	0,51	***	0.53	***
MER	-0,42	***	-0.40	***
SED	-0,69	***	-0.67	***
SFA	-0,14	***	-0.23	***
Free sugars	-0,40	***	-0.32	***
Sodium	0,04	**	-0.01	

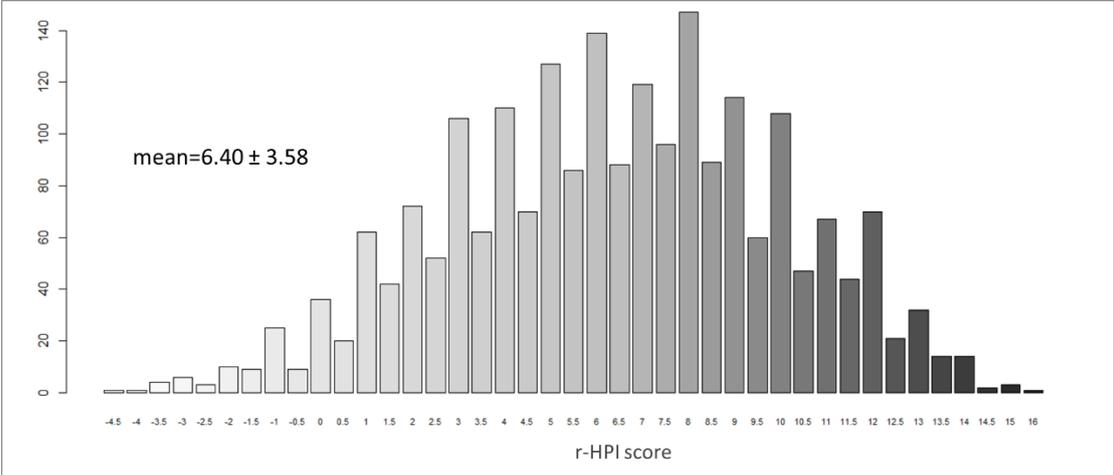
* p <0.1; ** p <0.05; *** p<0.001

Supplemental Table S6: Associations between the nutritional quality indicators (NRF 9.3, MAR, MER, SED) and the r-HPI of household food purchases across deciles of total expenditure (A), animal to plant protein ratio (B), “Alcoholic drinks” expenditure share (C), and “Mixed dishes” expenditure share (D) of the food basket, in the external validation sample (n=2,188) of households from the Kantar WorldPanel

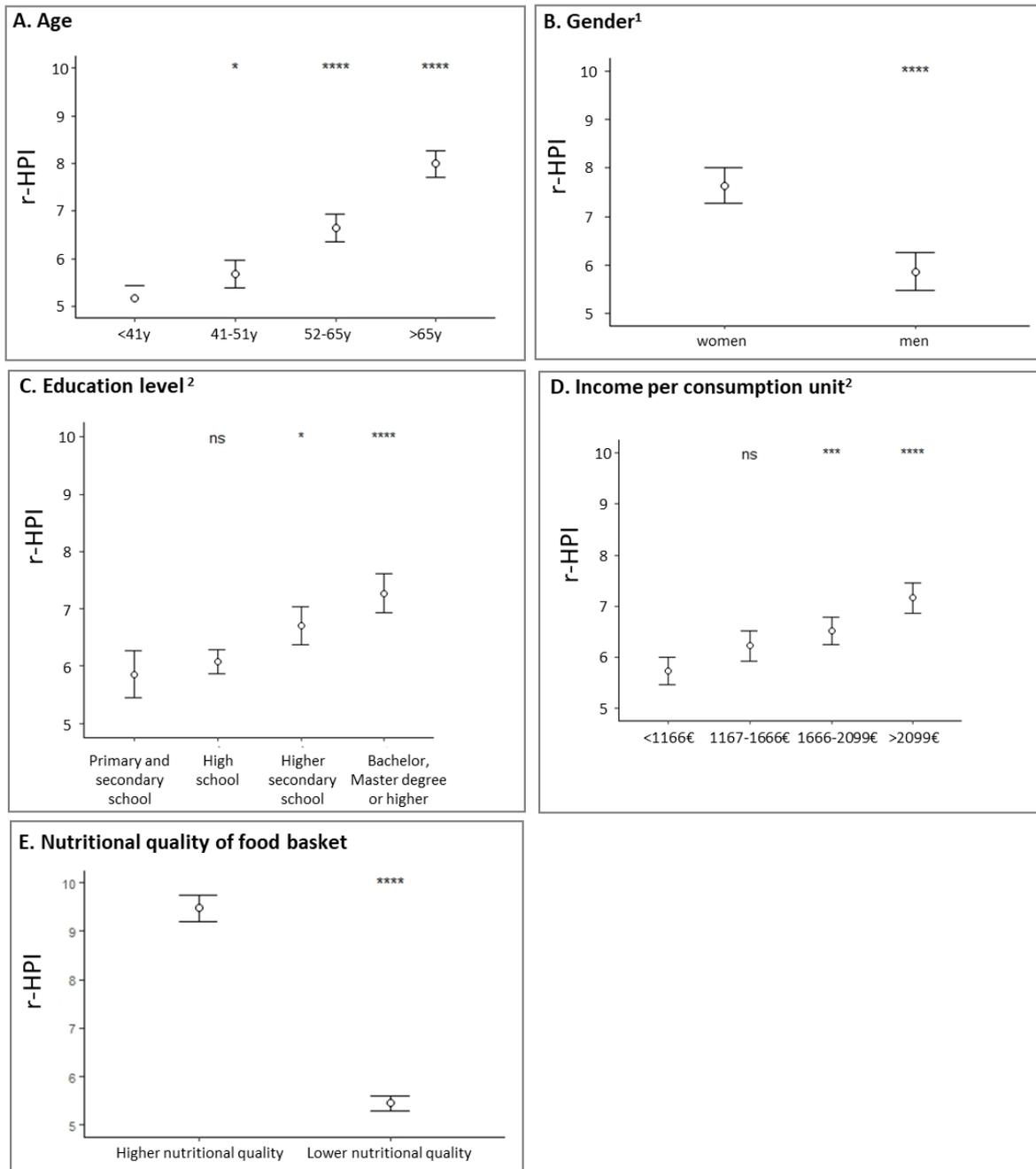
(A) Decile of total expenditure (€)	NRF 9.3¹	MAR¹	MER¹	SED¹
D1 : ≤ 111	0.529	0.522	-0.380	-0.607
D2 :]111 - 145]	0.555	0.447	-0.399	-0.648
D3 :]145 - 175]	0.595	0.495	-0.323	-0.635
D4 :]175 - 210]	0.640	0.516	-0.458	-0.674
D5 :]210 - 243]	0.620	0.483	-0.505	-0.708
D6 :]243 - 280]	0.626	0.530	-0.413	-0.733
D7 :]280 - 320]	0.612	0.519	-0.321	-0.673
D8 :]320 - 378]	0.589	0.504	-0.468	-0.675
D9 :]378 - 462]	0.652	0.589	-0.429	-0.755
D10 : > 461	0.625	0.601	-0.371	-0.757
(B) Deciles of animal to plant protein ratio	NRF 9.3¹	MAR¹	MER¹	SED¹
D1 : ≤ 1,68	0.605	0.591	-0.376	-0.705
D2 :]1,68 - 2,08]	0.587	0.535	-0.368	-0.674
D3 :]2,08 - 2,44]	0.659	0.593	-0.376	-0.695
D4 :]2,44 - 2,76]	0.615	0.582	-0.383	-0.694
D5 :]2,76 - 3,08]	0.610	0.547	-0.372	-0.691
D6 :]3,08 - 3,41]	0.664	0.582	-0.520	-0.695
D7 :]3,41 - 3,85]	0.551	0.519	-0.322	-0.755
D8 :]3,85 - 4,44]	0.504	0.497	-0.485	-0.614
D9 :]4,44 - 5,57]	0.661	0.545	-0.500	-0.684
D10 : > 5,57	0.523	0.473	-0.345	-0.595
(C) Deciles of “Alcoholic drinks” expenditure share	NRF 9.3¹	MAR¹	MER¹	SED¹
D1 : = 0	0.605	0.544	-0.476	-0.647
D2 : = 0	0.605	0.544	-0.476	-0.647
D3 : = 0	0.605	0.544	-0.476	-0.647
D4 :]0 - 1,44]	0.658	0.572	-0.453	-0.672
D5 :]1,44 - 3,19]	0.627	0.556	-0.427	-0.687
D6 :]3,19 - 5,22]	0.569	0.500	-0.311	-0.694
D7 :]5,22 - 8,39]	0.630	0.585	-0.458	-0.727
D8 :]8,39 - 13,24]	0.612	0.574	-0.374	-0.709
D9 :]13,24 - 21,21]	0.581	0.493	-0.487	-0.683
D10 : > 21,21	0.520	0.438	-0.281	-0.639
(D) Deciles of “Mixed dishes” expenditure share	NRF 9.3¹	MAR¹	MER¹	SED¹
D1 = 0.00	0.546	0.485	-0.354	-0.625
D2 :]0.00 - 1.33]	0.531	0.511	-0.252	-0.702
D3 :]1.33 - 2.57]	0.639	0.580	-0.439	-0.681
D4 :]2.57 - 3.58]	0.589	0.541	-0.382	-0.739
D5 :]3.58 - 4.99]	0.556	0.419	-0.373	-0.645
D6 :]4.99 - 6.38]	0.662	0.553	-0.485	-0.732
D7 :]6.38 - 8.49]	0.615	0.573	-0.445	-0.711
D8 :]8.49 - 11.20]	0.618	0.607	-0.414	-0.671
D9 :]11.20 - 15.89]	0.630	0.569	-0.445	-0.624
D10 > 15.89	0.583	0.527	-0.408	-0.585

¹ All associations were significant at p<0.001

Supplemental Figure S1: Distribution of the revised Healthy Purchase Index (r-HPI) (A) in the external validation sample (n=2,188) of French households from the Kantar Worldpanel



Supplemental Figure S2: Mean r-HPI by age (A), gender (B), and education level (C) of the respondent, income per consumption unit (D) and for households having a food basket of higher (MAR > median and MER and SED < median) vs. lower nutritional quality (E), in the external validation sample (n=2188) of French households from the Kantar Worldpanel. MAR: Mean Adequacy Ratio, MER: Mean Excess Ratio, r-HPI: revised Healthy Purchase Index, SED: Solid Energy Density



* $p \leq 0.05$, ** $p \leq 0.01$, *** $p \leq 0.001$; **** $p \leq 0.0001$; ns: $p > 0.05$ (Wilcoxon test or pairwise comparisons of contrasts according to the tested variable); ¹ For gender, estimates and tests were performed on a subsample of single adult households (n=703); ² Mean after adjustment for age