Association between ultra-processed food consumption and the nutrient profile of the Colombian diet in 2005

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Abstract

Objective. To evaluate the consumption of ultra-processed food and drink products and its association with the nutrient profile of the Colombian diet in 2005. **Materials and methods.** Food consumption based on 24-hour dietary records from 38 643 men and women was classified into four NOVA groups according to the extent and purpose of food processing. **Results**. Ultra-processed food and drink products represented 15.9% of the total energy daily intake, compared to 63.3% from minimally processed food, 15.8% from processed culinary ingredients, and 4.9% from processed food. Non-ultra-processed food items had a healthier nutritional profile compared to ultra-processed items in terms of contribution to total calories from protein, carbohydrates, total fat, saturated fat, free sugar, fiber and energy density. **Conclusions.** Ultra-processed food products have a less healthy nutrient profile than non-ultra-processed ones. An increase in the consumption of these foods must be prevented within Colombia.

Keywords: processed food; diet; macronutrients; classification; NOVA; Colombia

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Resumen

Objetivo. Evaluar el consumo de alimentos y bebidas ultraprocesadas y su asociación con el perfil nutricional dentro de la Encuesta Nacional de Nutrición de 2005 en Colombia. **Material y métodos.** El consumo de alimentos basados en registros alimentarios de 24 horas de 38 643 individuos se clasificó en cuatro grupos de NOVA. **Resultados.** Los productos de alimentos y bebidas ultraprocesados representaron 15.9% de la ingesta diaria total de energía, en comparación con 63.3% de los alimentos mínimamente procesados, 15.8% de los ingredientes culinarios procesados y 4.9% de los procesados. Los alimentos mínimamente procesados tenían un perfil nutricional más saludable en comparación con los artículos ultraprocesados en términos de contribución a las calorías totales, de proteínas, carbohidratos, grasa total, grasa saturada, azúcar libre, densidad de fibra y densidad de energía. **Conclusiones.** Los alimentos ultraprocesados tienen un perfil nutricional menos saludable que los alimentos no procesados.

Palabras clave: alimentos procesados; dieta; macronutrientes; clasificación; NOVA; Colombia

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The use of the NOVA classification system, developed to study the impact of food processing on diet quality and health outcomes, has shown consistent associations between consumption of ultra-processed food and drink products (UPF) and obesity,[1] metabolic syndrome,[2] and dyslipidemia.[3] More recently, the consumption of UPF was associated with higher nine-year incidence of overweight and obesity and hypertension in a Spanish cohort of middle-aged adult university graduates.[4] Although the mechanisms by which these foods are linked to weight gain and metabolic impairments still need to be fully determined, some explanations have been put forward.

Several studies show that UPF, as a group, are more fatty, sugary, salty and energy-dense than are all other food groups taken together, in Canada,[5] the United States,[6] the UK,[7] Brazil,[8-10] and in Chile.[11,12] Additionally, UPF, have a high glycemic load, are often sold in large portion sizes, are formulated to be extremely palatable and habit-forming,[13] and are aggressively advertised and marketed.[14] Furthermore, they stimulate appetite,[15] and are more likely to be eaten mindlessly.[16] Current evidence suggests that consumption of sweetened ultra-processed beverages such as soft drinks have less impact on satiety compared to solid food.[17] In contrast, minimally processed food have been found to be more satiating and less hyperglycemic.[18]

UPF contribute to more than 50% of the daily energy intake in high-income countries such as the US,[6] and Canada,[5] while lower values are found in middle-income countries such as Brazil (21.5%),[8] Mexico (29.8%),[19] and Chile (28.6%).[12] Given recent changes in market deregulation in Colombia and the introduction of a Trade Promotion Agreement (TPA) with the United States, greater access to UPF is expected in the near future.[20] It is likely that traditional diets and cultural aspects related to eating habits will change, as has been the case in other Latin American countries.[21,22]

There have been few prior examinations of the consumption of UPF within a representative Colombian population. In order to address this gap, this study uses the NOVA classification system, to quantify the intake of UPF in the Colombian population. It also assesses the relationship between UPF and the nutrient profile of dietary intake in Colombia in 2005.

Materials and methods

Data source, population and sampling

This study uses data from the first National Nutrition Survey and the Demographic and Health National Survey of Colombia (known as ENDS in Spanish – *Encuesta de Demografia y Salud*), conducted between October 2004 and July 2005 by the Colombian Institute of Family Welfare (ICBF) and *Profamilia*. The Ethics committee from the respective organizations (Profamilia and ICBF) reviewed and approved the study methods and procedures. The survey used a stratified, multistage, cross-sectional design to obtain national and sub-regional representativeness (16 sub-regions), with oversampling of rural areas and low socioeconomic status (SES) groups. It included 99% of the urban and rural population with a response rate of 74%.[23] The sample size and sampling design were intended to provide proportion and prevalence estimates, and model associations.

A secondary data analysis was performed using information from men, women and children between the ages of 2 and 64 years who completed an interviewer-administered 24-hour recall. The 24-hour dietary recalls were distributed randomly within the week to include week and weekend days. Sixty plastic models and figures were used to help participants better estimate the amount, quantity and weight of the particular food consumed. The food models have been previously standardized.[24] Color photographs were used for the estimation of beverages. The interviewer registered the type of food, the name of the preparation, the ingredients and the amount consumed as informed by the respondent. The person responsible for preparing the food had to be present during the interview to answer any questions. If the food consumed by a child was at the school or daycare center, the interviewer, accompanied by a supervisor, visited the school to get detailed information on the preparation of the food. Quality control and supervision was done throughout the entire data collection process and the interview was repeated in the case of inconsistencies.[23]

Categorizing food consumption using the NOVA classification system

Food intake (1 053 food items) was first classified into one of four NOVA groups.[25] The groups – unprocessed or minimally processed food, processed culinary ingredients, processed food and UPF - are mutually exclusive and vary in their extent and purpose of processing. Food items were then further categorized into one of 31 subgroups (table I). In some cases, it was not possible to access detailed information for a typical culinary preparation, or to disaggregate these recipes into their constituent ingredients (e.g. ´buñuelos´, ´empanadas´, ´natilla´). Since the main ingredient in these recipes was a minimally processed food (group 1) and a processed culinary ingredient (group 2), these aggregated

Table I

ABSOLUTE AND RELATIVE MEAN CONSUMPTION OF FOOD ACROSS NOVA CATEGORIES, 2005 COLOMBIAN NATIONAL NUTRITION SURVEY (N=38 643)

NOVA group/subgroup	*Kcal/day*		*Total energy intake (%)*	
	Mean	*SE*	*Mean*	*SE*
Total kcal	1 835.1	12.0	-	-
Unprocessed or minimally processed food	1 133.3	6.5	63.3	0.3
Plantains, roots, tubers, flour	288.7	5.7	16.0	0.4
Cereal grains, flours	247.2	2.9	14.2	0.2
Freshly prepared food*	136.1	3.3	7.1	0.2
Milk, yogurt (plain)	98.4	1.8	5.5	0.1
Red meat	94.2	1.8	5.1	0.1
Fruit‡	64.4	2.0	3.6	0.1
Beans, pulses, legumes, flour	64.3	1.9	3.5	0.1
Eggs	43.5	0.8	2.5	0.0
Poultry	37.7	1.1	2.2	0.1
Vegetables	27.1	0.6	1.6	0.0
Fish, seafood	12.2	0.9	0.8	0.1
Freshly made fruit juice	4.6	0.3	0.3	0.0
Others§	15.1	0.6	0.9	0.0
Processed culinary ingredients	284.7	3.5	15.8	0.2
Sugar (honey, molasses, maple syrup)	155.4	3.1	8.9	0.2
Plant oils	115.4	1.6	6.1	0.1
Animal fats (butter, lard and cream)	13.8	0.7	0.8	0.0
Others#	0.1	0.0	0.0	0.0
Processed food	104.3	2.7	4.9	0.1
Cheese	36.8	1.3	1.9	0.1
Fresh breads, fresh bakery products	36.2	1.5	1.7	0.1
Meats (canned, smoked, preserved)	3.9	0.3	0.2	0.0
Others&	27.7	2.1	1.2	0.1
Ultra-processed food	312.7	7.1	15.9	0.3
Industrial breads	89.4	2.6	5.0	0.1
Packaged snacks (sweets, savory)∞	50.3	1.7	2.5	0.1
Sugar sweetened beverages°	49.4	1.5	2.5	0.1
Confectionery (chocolate, candy, sweets)	28.5	1.2	1.5	0.1
Sausages, reconstituted meat products	29.1	1.4	1.3	0.1
Ready-to-eat meals€	14.3	1.2	0.6	0.0
Desserts	10.1	0.5	0.5	0.0
Breakfast cereals	5.1	0.3	0.3	0.0
Milk-based drinks£	3.8	0.3	0.2	0.0
Others¢	32.7	2.7	1.4	0.1

* Includes pasta, sweet and savory food that could not be disaggregated into individual ingredients
‡ Includes fruit pulp, coconut water
§ Includes cocoa, insect meat, coconut milk, soy milk, nuts, coffee, tea, tofu
# Includes spices, vinegar, yeast, vanilla extract, unflavored gelatin
& Includes preserved fruit, preserved vegetables, salted, sweetened or oil roasted nuts or seeds, condensed milk, beer and wine
∞ Includes chips, crackers, wafers, cookies
° Includes fruit drinks
€ Including frozen food, frozen pizza, soups, instant noodles
£ Includes custards, sweetened yogurts, milkshakes
¢ Includes spreads, margarine, broths, sauces, commercial baby food and distilled alcohol

preparations were classified as 'freshly prepared food' and classified as a subgroup within unprocessed or minimally processed food (59 food items or 5.6% out of 1 053 total items).

Energy and nutrient intake was calculated for every food item and every respondent using a software developed by the School of Nutrition and Dietetics at the University of Antioquía, in Medellín, Colombia.[24] Total energy (kcal), energy density (kcal/g for solids only - excluding beverages like juice, milk and milk-based drinks, sugar sweetened drinks), total protein, carbohydrates, free sugars, fats, saturated fats, and fiber (g/1 000 kcal) were also estimated. Energy density was calculated by dividing the number of kilocalories of solid food (liquids were excluded) by the amount consumed, in grams (considered the weight as consumed i.e. cooked versus raw), for each food. The amount of free sugars in each of the 1 053 food items reported in the survey was not available in the *Encuesta Nacional de la Situación Nutricional* (ENSIN) data set, and was estimated by the authors based on the total sugar content of identical or similar food items found in the Colombia Nutritional Information Table,[24] the United States Department of Agriculture (USDA) food composition table,[26] or from nutrition labels found in local supermarkets. Based on the Pan-American Health Organization (PAHO) Nutrient Profile Model, depending on the product, free sugars were equal to declared added sugars, declared total sugars (sugary drinks and confectionery), 75% of total sugars (granola bars) or 50% of total sugars (flavored milk and yogurt, fruit in syrup).[27]

Data management and analysis

The ENSIN data was merged with the demographic information contained in the ENDS data to link food consumption with individual level information on education, socioeconomic status, sex, age and place of residence. Responses with missing data on total energy, with extreme total energy intakes (<200 kcal and >5 000 kcal) and responses from pregnant women were excluded from the analysis. The final sample size included 38 643 individuals. The study population's absolute and relative consumption of energy (% of total energy intake) was analyzed across the four NOVA groups and the 31 subgroups. Student's *t*-tests were used to compare the average nutrient content of non-UPF (unprocessed/minimally processed food, processed culinary ingredients and processed food) and UPF, across individuals within the sample. The nutrient content was compared to recommended value ranges from the World Health Organization for free sugar intake, total fats, saturated fats, protein, and dietary fiber,[28-32] and from the World Cancer Research Foundation for energy density.[33]

Individuals were classified into quintiles based on the dietary contribution of UPF (% of total energy intake). The average content of each nutrient (protein, carbohydrates, free sugars, total fats, saturated fats, energy density, and dietary fiber) was assessed in the overall diet and compared across quintiles. Crude and adjusted standardized regression coefficients were used to identify the direction and the statistical significance of the association between quintiles of the dietary contribution of UPF and the content of nutrients. Adjusted analysis accounted for socioeconomic strata, place of residence, education, age and sex. The 2004-2005 ENDS sample weights were used in all analyses to account for differential probabilities of selection. All data analyses were performed STATA 14.

Results

The mean age of this Colombian sample was 26.5 years (±0.2 years). A majority of the sample was female (51.9%), of lower-middle socioeconomic status, with secondary education or higher (46.9%). Over 70% of the participants resided in urban areas (table II).

The average daily energy intake from all food and drinks was 1 835 kcal. Unprocessed or minimally processed food accounted for 63.3% of total energy intake, processed culinary ingredients contributed 15.8%, and processed food and UPF accounted for 4.9 and 15.9% respectively (table I). The contribution of culinary preparations to total energy intake, calculated by combing energy intakes from unprocessed or minimally processed food and processed culinary ingredients was 1 418 kcal or 79.1%. Within the unprocessed or minimally processed food category, the largest contributors to energy intake were plantains, roots and tubers (16.0%), followed by cereal grains and flours (14.2%). Freshly prepared food (preparations of primarily unprocessed food) accounted for 7.1% of the total energy, milk and yogurt contributed 5.5%, and red meat and fruits contributed 5.1 and 3.6% respectively.

Among the processed culinary ingredients, sugars were the largest contributor to total energy (8.9%), followed by vegetable oils (6.1%). In the processed food category, the largest contribution came from cheese (1.9%), followed by fresh bread and bakery products (1.7%). Within UPF, the largest contributor to total energy intake were industrial breads (5.0%), sugar-sweetened beverages (2.5%) and packaged sweet and savory snacks (2.5%). Sausages and reconstituted meat (1.3%), confectionery (1.5%) were some of the other subcategories of importance.

The average Colombian diet met WHO recommendations for protein (12.8% compared to the recommendation of 10-15%), carbohydrates (64.6%, compared to the recommendation of 55-75%), total fats (24.8%, compared to the recommendation of 15-30%), and saturated fats (8.6%, recommended value <10%) (table III). However, the fiber density of the average diet was below recommended levels (11.0 g/1 000 kcal compared to the recommendation of 12.5g/1 000 kcal), while average energy density, and free sugars clearly exceeded the recommendations. Average values for energy density were 1.5 kcal/g (recommended range 1.25 g/kcal - 1.45 g/kcal), and 14.1% for free sugars (<10% is recommended).[32]

Table II
Participant demographics, 2005 Colombian National Nutrition Survey (N=38 643)

Age, years (mean, SE)	*26.5*	*0.2*
	*N**	*%‡*
Sex		
Female	19 688	51.9
Male	18 955	48.1
Age range, years		
2-9	12 314	18.5
10-19	14 674	23.0
20-34	5 708	26.3
35-49	3 806	20.0
≥50	2 141	12.2
Socioeconomic status		
Level 1	15 010	29.4
Level 2	14 248	36.9
Level 3	8 379	28.5
Level 4	1 006	5.1
Education§		
Preschool/no education	7 958	14.1
Primary education	13 711	34.0
Secondary education	12 828	34.9
Higher education	2 378	12.0
Residential area		
Urban area	29 244	73.4
Central (populated)	5 285	15.2
Rural (dispersed)	4 114	11.4
Geographic region		
Atlantic	10 317	25.3
Oriental	4 581	16.8
Central	7 126	23.8
Pacific	4 940	16.9
Bogota	1 806	15.9
Orinoquia and the Amazons	9 873	1.1

* Unweighted counts
‡ Weighted percentages, may not add up to 100 due to rounding
§ Education has 1 629 missing variables

Table III
NUTRIENT DISTRIBUTION ACROSS ULTRA-PROCESSED AND NON-ULTRAPROCESSED ITEMS. 2005 COLOMBIAN NATIONAL NUTRITION SURVEY (N=38 643)

	Overall diet (N=38 643)		*Non-ultra-processed items (N=38 634)*		*Ultra-processed items (N=32 790)*		*Recommended intakes*
	Mean	*SE*	*Mean*	*SE*	*Mean*	*SE*	
Mean % of total energy intake from:							
Total proteins	12.8	0.07	13.8	0.1	8.8*	0.1	10-15%‡
Total carbohydrates	64.6	0.3	64.3	0.3	65.2	0.4	55-75%‡
Free sugars	14.1	0.2	12.1	0.2	25.3*	0.9	<10%§
Total fats	24.8	0.2	24.8	0.3	25.5	0.4	15-30%‡
Saturated fats	8.6	0.08	8.6	0.1	8.4	0.1	<10%‡
Mean fiber density (g/1 000 kcal)	11.0	0.09	11.9	0.1	5.4*	0.1	>12.5g/1 000 kcal‡
Mean energy density of solid food (kcal/g)	1.5	0.007	1.4	0.0	3.1*	0.0	1.25-1.45 kcal/g#,&

* p <0.001 for the comparison with non ultra-processed food
‡ World Health Organization, 2003[30]
§ World Health Organization, 2015[32]
# Energy density was calculated by adding calories consumed from solid food, divided by the amount consumed in grams
& World Cancer Research Foundation (WCRF). Energy Density: findings the balance for cancer prevention. London: World Cancer Research Foundation, 2009[33]

Not surprisingly, the nutrient profile of non-ultra-processed items most closely aligned with recommended intake levels. UPF, however, did not meet recommendations for energy density, fiber density, protein, and free sugars. At 25.3%, the free sugar content of UPF was more than twice the recommended level. Between groups comparisons further highlighted the discrepancies in nutrient levels. The energy density of UPF was twice as much as that of non-UPF (3.1 *vs* 1.4 kcal/g), fiber density was nearly half (5.4 *vs* 11.9 g/1 000 kcal) and protein content was also much lower (8.8 *vs* 13.8%).

Significant differences were also found in the nutrient profile across quintiles of UPF consumption. Compared to the lowest quintile, the quintile with the highest intake UPF had substantially higher daily total energy intake (1 511 kcal *vs* 2 039 kcal), greater energy density and larger percentage contributions to total energy from free sugars, total fats, and saturated fats (table IV). There was a significant reduction in fiber density and percentage contribution to total energy from protein and carbohydrates from the lowest to the highest quintile. After adjusting for sociodemographic variables, a positive and statistically significant trend was found between quintiles of the dietary share of UPF and the dietary energy density (β: 0.24) and the content of free sugars (β: 0.14), total fats (β: 0.16), and saturated fats (β: 0.22). In contrast, a negative and statistically significant trend was observed for dietary content of carbohydrates (β: -0.19), protein (β: -0.07) and fiber (β: -0.26).

Discussion

In 2005, the Colombian diet was largely based on culinary preparations made of unprocessed or minimally processed food, culinary ingredients, and processed foods. Plantains and tubers and cereal grains were the largest sources of energy in the diet, with some important contributions from red meat and poultry. The overall dietary share of fresh or minimally processed foods in Colombia (63.3%) was much higher than in Chile (33.8%),[12] Canada (39.2%),[5] and the US (29.6%),[34] and similar to Brazil (58%). However, the nutrient profile of the Colombian diet did not quite align with recommended consumption levels. For instance, while the proportion of energy from protein, carbohydrates, total and saturated fat was adequate, levels of free sugars, and energy density were at higher than recommended levels while fiber was less than recommended.

The Colombian diet composed of only non-UPF had a healthier nutrient profile than the UPF component. It had significantly healthier levels of protein, fiber, and energy density, and while free sugars intake was still higher than recommended levels, it was less than half of the levels seen in the UPF component. These results are similar to those found in a recent study within a

Table IV

Nutrient profile of the Colombian diet across quintiles of ultra-processed food, 2005 Colombian National Nutrition Survey (N=38 643)

Nutrient profile indicators	Quintiles (Q) of the dietary share of ultra-processed food (% of total energy, unadjusted)*					Standardized regression coefficients‡	
	Q1 1 511 kcals N =7 700	Q2 1 879 kcals N=7 748	Q3 1 873 kcals N=7 758	Q4 1 889 kcals N=7 744	Q5 2 039 kcals N=7 693		
Mean % of total energy intake from:						Crude	Adjusted§
Total proteins	12.5	12.8	13.1	13.1	12.4#	-0.01#	-0.07#
Total carbohydrates	68.9	66.3	64.7	63.1	59.2#	-0.27#	-0.19#
Free sugars	12.4	13.5	14.1	14.7	15.9#	0.12#	0.14#
Total fats	21.8	23.9	24.6	25.9	27.6#	0.24#	0.16#
Saturated fats	7.3	8.0	8.4	9.1	10.4#	0.27#	0.22#
Mean fiber density (g/1 000 kcal)	12.8	11.7	11.2	10.5	8.6#	-0.28#	-0.26#
Mean energy density in solid food (kcal/g)&	1.4	1.4	1.5	1.5	1.8#	0.28#	0.24#

* Mean (range) dietary share of ultra-processed foods/quintile: 1st=0.2 (0-1.6); 2nd=5.6 (1.6-9.3); 3rd=13.2 (9.4-17.2); 4th=22.5 (17.3-28.7); 5th=41.1 (28.8-100)
‡ Coefficients from nutrient profile indicators regressed on quintiles of the dietary share of ultra-processed food and expressed in standard deviation units
§ Adjusted for age, sex, zone and regions of residency, socioeconomic status and education
# $p<0.01$ for linear trend across quintiles
& Energy density was calculated by adding calories consumed from solid food only, divided by the amount consumed in grams

representative sample of children (5-12 y) from low- to middle income families in Bogota.[35] The authors found that processed and UPF had a less healthy nutrition profile compared to minimally processed foods; in particular, the processed and UPF were lower in essential vitamins and higher in sodium and trans-fats.

Industrialized breads, packaged snacks, sugar sweetened beverages and confectionery were the most commonly consumed categories of UPF in Colombia. Sugar sweetened beverages form a large proportion of UPF in other South American countries as well. In Brazil they are the third largest contributor of energy among UPF, preceded only by desserts and fast food,[8] while in Chile they are the primary contributor of energy.[12] Besides contributing to the overall energy intake, sugar sweetened beverages are also an important source of free sugars in the Colombian diet. Along with confectionary, and the use of table sugar in the preparation of coffee, fruit juices and desserts, they explain the high free sugars level of the Colombian diet. As demonstrated by the results of this study, participants in the first quintile of UPF intake, where calories from these foods represented 0.2% of total intake, still derived 12.4% of their total calories in the form of free sugars. Given the overwhelming evidence on the negative effects of sugar on human metabolic health, recommendations to avoid or limit UPF and to use sugar in moderation when preparing drinks, dishes meals, are essential in Colombia.

Beyond increasing free sugars content, a higher consumption of UPF seems to displace fiber-rich, minimally processed food. In our study, as the dietary share of UPF increased, the fiber density significantly decreased as the energy density, and the proportion of total fats and saturated fats of the diet increased. This macronutrient profile of UPF is also mirrored among diets in Brazil,[1] Canada,[5] and the US,[34] suggesting that a higher dietary share of UPF lowers the overall nutritional diet quality.[1] The observed association between the increasing consumption of UPF and lowered diet quality is highly relevant given the negative effects of high energy density, high intake of free sugars, and saturated fats and low intake of fiber [29] on cardiovascular health, obesity and mortality.

Some limitations of this study should be highlighted. These include measurement errors, and the inability to obtain additional information from the respondents. The authors worked closely with the statisticians who developed the actual surveys and the sampling strategy to minimize any errors in the analysis of derived variables. In addition, misclassification of the food using NOVA was minimized by employing an iterative process with multiple expert consultations. In some

cases, it was not possible to disaggregate certain culinary preparations into their constituent ingredients or precisely measure the free sugar content of food items (this was estimated using PAHO recommendations) which may have resulted in some loss of precise information. In addition, some typical culinary preparations which were impossible to disaggregate were mostly classified as unprocessed or minimally processed foods. As a result, the macronutrient content from these foods could have been overestimated since it was not possible for us to disaggregate into groups 1 and 2. The total contribution of this food group (culinary preparations) was 7.1% of the total energy in the diet. Future surveys should be designed to collect information on food processing to allow for the use of NOVA, as suggested by FAO.[36] Finally, data was used from the only available National Nutrition Survey that allowed for categorization of food intake collected using a 24-hour recall diary. Food intake data from the most recent nutrition surveys in Colombia use food frequency questionnaires, which make using the NOVA classification more challenging.

Conclusion

Ultra-processed foods have a less healthy nutrient profile than non-ultra-processed food. An increase in the consumption of these foods must be prevented within Colombia, which still sources mostly of its caloric consumption from unprocessed and minimally processed foods. These preventive measures may include marketing regulations, taxation, or labelling, similar to those under consideration in other Latin American countries. On the other hand, continued intake of unprocessed and minimally processed food must be incentivized along with raising consumer awareness of the benefits of eating freshly cooked food.

Declaration of conflict of interests. The authors declare that they have no conflict of interests.

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