Contribution of NOVA food groups to energy and nutrient supply in Mexican households

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Romo-Aviles M, Ortiz-Hernández L. Contribution of NOVA food groups to energy and nutrient supply in Mexican households. Salud Publica Mex. 2019;61:155-165.
https://doi.org/10.21149/8923

Abstract

Objective. To analyze the contribution of natural, processed and ultra-processed foods to energy and nutrient supply in Mexican households. **Materials and methods.** The database of the National Household Expenditure Survey 2013 was analyzed (n=58 001), which is a cross-sectional survey. Food supply (g/adult equivalent/day) and energy, macro- and micro-nutrient supplies were estimated. Foods were classified following the NOVA system. Households sociodemographic characteristics were analyzed as covariates. **Results.** Natural foods (NF) contributed with more energy (55.0%) followed by ultra-processed foods (UPF, 21.2%). NF were the main source of most nutrients. Processed culinary ingredients (PCI) and processed foods (PF) had high content of energy, total fats, and saturated fats, but low content of certain micronutrients. Sodium was mainly available in PF (34.6%) and UPF (31.4%). Sugar-sweetened beverages, fast foods, and biscuits and cookies were the main UPF in terms of energy supply. **Conclusions.** In Mexican households, the PCI, PF and UPF had low nutritional quality.

Keywords: food-processing industry; food quality; micronutrients; nutritive value

Romo-Aviles M, Ortiz-Hernández L. Contribución de los grupos de alimentos NOVA a la disponibilidad de energía y nutrientes en los hogares mexicanos. Salud Publica Mex. 2019;61:155-165.
https://doi.org/10.21149/8923

Resumen

Objetivo. Analizar la contribución de los alimentos naturales, procesados y ultraprocesados a la disponibilidad de energía y nutrientes en los hogares mexicanos. **Material y métodos.** Se analizó la base de datos de la Encuesta Nacional de Gasto de los Hogares 2013 (n = 58 001), la cual es una encuesta transversal. Se estimó la disponibilidad de alimentos (g/adulto equivalente/día), energía y nutrientes. Los alimentos fueron clasificados siguiendo el sistema NOVA. **Resultados.** Los alimentos naturales (AN) y los ultraprocesados (AUP) contribuyeron con más energía. Los AN fueron la principal fuente de la mayoría de los nutrimentos. Los ingredientes culinarios procesados (ICP) y los alimentos procesados (AP) tenían alto contenido de energía, grasas totales y grasas saturadas pero bajo contenido de ciertos micronutrientes. El sodio estaba disponible principalmente en AP y AUP. Las bebidas azucaradas, comidas rápidas, galletas y panes fueron los principales AUP. **Conclusión.** En México, los ICP, AP y AUP tienen baja calidad nutricional.

Palabras clave: industria de procesamiento de alimentos; calidad de la dieta; micronutrientes; valor nutritivo

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Received on: July 6, 2017 • **Accepted on:** December 18, 2018
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According to the NOVA system, foods can be classified in four categories based on the industrial processes applied to preserve, extract, modify or create them:[1] a) natural or minimally processed (from now on named *natural*) are edible parts of plants or animals; and foods with processes to extend their life, such as freezing or drying; b) processed culinary ingredients are ingredients from natural foods used for seasoning, cooking and preparing dishes; c) processed foods are natural foods with added ingredients to extend their durability or make them more palatable; and d) ultra-processed food and drink products are packaged foods with five or more ingredients, ready to eat, drink or heat. Usually, ultra-processed foods or beverages are ready-to-consume foods and were produced mainly from substances extracted or refined from natural foods or synthesized by organic material.[2,3]

Urbanization and the increasing participation of females in the labor market has been accompanied by greater disposable income in households but less time spent preparing food at home.[4] This has influenced the purchase of ready-to-eat foods or easily accessible snacks, including processed and ultra-processed foods.[5] In addition, ultra-processed foods are normally sold in large quantities, they tend to have pleasant flavors, and their striking packages and marketing encourage their acquisition.[6,7] All these factors promote the consumption of ultra-processed foods; consequently, the intake of natural or minimally processed foods decreases.

A higher intake of ultra-processed foods has been associated with an increase of low density lipoproteins and total cholesterol,[8] higher body mass index,[5,9] higher risk of overweight and obesity,[10] hypertension,[11] and metabolic syndrome.[12] And, as supported in previous analysis,[2] ultra-processed foods are unhealthy and cannot comply with World Health Organization recommendations for total fats, sugars, salt and energy density.

Evidence from industrialized countries indicates that ultra-processed foods generally contain more added sugars, salt, and total fats and are more energy dense than natural or minimally processed foods.[2,3,6] Ultra-processed foods also tend to have less fiber, micronutrients and phytochemicals, and they have a higher glycemic load and artificial substances such as colorants or flavorings. However, in each society, the specific ultra-processed foods that are available differ, and therefore, the nutrient supply can differ too. For example, the main ultra-processed foods consumed in Canada[13] are soft drinks, fruit drinks, and fruit juices; meanwhile, in the United States of America,[14] they are breads. This evidence shows that it is necessary to know the specific types of ultra-processed foods that are available in each country. This information could inform policies and programs aimed to promote healthy eating in the Mexican society.

Data about availability and consumption of ultra-processed foods and beverages in Mexico is scarce. It is estimated that the sales of ultra-processed foods is 220 kg / year / person.[5] Recently estimates of contribution of ultra-processed foods to energy consumption based on 24h recall and differences by sociodemographic characteristics were reported.[15] However, the nutritional quality (and not only energy) of each food group (natural, processed culinary ingredients, processed, and ultra-processed) is unknown; as well as sociodemographic characteristics of the population that acquires each food group.

Therefore, the aims of the present study were: a) to analyze the contribution of natural or minimally processed foods, processed culinary ingredients, processed, and ultra-processed foods to energy and nutrient supply in Mexican households; b) to identify the main ultra-processed foods available in Mexican households; and c) to identify socioeconomic and demographic factors associated with the availability of natural foods, processed culinary ingredients, processed, and ultra-processed foods at the household level.

Materials and methods

The database of the National Household Expenditure Survey (Engasto by its acronym in Spanish: *Encuesta Nacional de Gasto de los Hogares*) conducted in Mexico from January 2013 to January 2014, was analyzed.[16] The Engasto is a cross-sectional survey conducted in Mexico and its main objective was to obtain the distribution of all households' expenditures on goods and services. One of its specific objectives was to estimate the annual consumption of food, beverages, electricity, gas, and water. The sampling of the Engasto was probabilistic with a bi-phase sample design, stratified by clustering, where the last selection unit was dwellings and the observation units were households. Primary sampling units were constituted by census tracts conformed to dwelling groups with similar socioeconomic characteristics. The sample included 71 851 households nationwide; however, the analytic sample consisted of 58 001 households. The exclusion criteria were households that did not have food availability data or those with energy and nutrient supplies that were five standard deviations (SD) above the nutrient average.

Participation in the Engasto is compulsory because it is part of the governmental system of information; therefore, confidentiality is guaranteed to participants. In addition, the databases are released to the public without any personal information that could be used to identify specific participants. The ethics of the project

(i.e. analysis of the Engasto database) was granted by the Ethic Committee of the Divisional Council of Biological and Health Sciences of the Metropolitan Autonomous University at Xochimilco.

In the Engasto, the interviewees were trained to register any foods and beverages purchased during a two-week period in the households. Interviewees were the people in charge of household management and/or organization. Trained interviewers reviewed the information registered by the interviewee and made clarifications or probed for missing data. The respondents reported any kind of foods and beverages acquired during the two weeks of the interview by any member that was living in the household. The reported foods were categorized, by the interviewers, into 224 categories of most-consumed single items (e.g., lettuce) or less-consumed food classes (e.g., chard, spinach, and purslane).

Standardized procedures to clean and analyze the data from household expenditure surveys were followed.[17,18] Beverages included in the Engasto were reported in milliliters; in these cases, the FAO/INFOODS Density Database Version 2.0[19] was used to convert millimeters into grams using their density (g/ml). The adult equivalent estimation was used to make equivalences among households based on the age of their members; in this way, children received a lower weighting than adults, and these ponderations were considered to obtain the adult equivalent. Values for the estimation of equivalent adults were specific to the Mexican population.[20] The weighted average of adult equivalent in the Engasto sample was 3.48. For food supply analysis, the amount of food available in each household was estimated dividing the total grams per day by the adult equivalent estimation (g/day/adult equivalent). Subsequently, food supply data greater than five SD of the average of food supply per adult equivalent were truncated. Foods were classified into one of the four groups of the NOVA system,[1] which classifies foods and beverages based on the industrial processes applied to preserve, extract, modify or create them: natural and minimally processed foods, processed culinary ingredients, processed foods, and ultra-processed food and drink products. Ultra-processed foods were subclassified for energy supply analysis. Sub-groups for this classification were the following: sweetened beverages, fast foods, packaged cereals, biscuits and cookies, oils, french fries and snacks, milk and yogurt, alcoholic beverages, texturized soybean, and sauces. Food classification and subclassification can be consulted in the supplementary table I (located in the repository Dataverse, DOI: https://doi.org/10.7910/DVN/EOHTRJ**)**.

Energy, fiber, carbohydrates, proteins, total fats, saturated fats, cholesterol, vitamin A, vitamin C, calcium, iron, magnesium, potassium, zinc and sodium supplies were estimated. This nutrients were selected because they are risk or protection factors for diseases that are main causes of morbidity or mortality in Mexico.[21-24] High energy intake is associated with weight gain; sodium and potassium are associated to hypertension; saturated fats, cholesterol, and sodium intakes are associated with coronary heart disease and stroke; calcium is associated with osteoporosis; iron and vitamin A are related to anemia; fiber, vitamin A, and vitamin C are protectors for some chronic conditions; and, zinc, vitamin A, and protein are related to linear growth. Whereas vitamin D, E and folate are also important nutrients for a healthy living, they were not available in the national reference that was used for the nutrimental information.[25]

For the content of energy and nutrients, the national food composition reference[25] was consulted. When nutrient data were not found in such reference, the USDA Food Composition Database version 2.3.7 was used.[26] The edible portion of foods to estimate the net weight was obtained from the national food composition reference.[25] Information about the codes used for nutrient estimations can be requested from the authors. All estimations were made based only on foods with nutritional information and adjusted by adult equivalent. A zero value was assigned when a food or beverage was not acquired, in this way all households were included in all analyses independently whether any item was available or not. Energy was estimated as kcal per day, as percentages of calories from natural food, processed culinary ingredients, processed, and ultra-processed foods, and as energy density (kcal/gram of food). Macronutrients were expressed as grams, percentage of total energy supply, and percentage of energy from natural food, processed culinary ingredients, processed, and ultra-processed foods. Micronutrients were expressed as nutrient density per 1 000 kcal of each food group.

The energy and nutrient content of the percentage of the edible portion of 185 of the 224 foods included in the Engasto were estimated. For the rest of the foods and beverages, it was not possible to estimate the energy and nutrient content because their description was unspecific. The term used for these items was *other* e.g., other vegetables. This label was used for the following natural foods: corn products, rice products, beef cuts, chicken parts, fowl, meat, animal viscera, fresh or frozen seafood, milk products, eggs, fruits with big seeds, frozen fruits, vegetables, aromatic herbs and spices, chilli and grain pulses. The label other was used for the following processed foods: sausages and processed meat, frozen or fresh prepared meat, cheese, animal fat, and processed pulses. The *other* ultra-processed products were: prepared, precooked and frozen products;

Table I

Absolute value and percentage of energy and nutrients supply of households provided by each NOVA food group in Mexican households, 2013

		Absolute					Percentage			
	Unit	N	PCI	P	UP	Total	N	PCI	P	UP
Food 1	g	1 380.3	47.7*	83.5*‡	303.2*‡§	1 814.6	72.3	3.3*	5.2*‡	19.3*‡§
Food 2	g	1 351.5	47.7*	78.0*‡	300.5*‡§	1 777.6	72.1	3.3*	5.0*‡	19.6*‡§
Energy	Kcal	933.2	249.5*	172.6*‡	325.1*‡§	1 680.4	55.0	12.8*	11.0*‡	21.2*‡§
Carbohydrates	g	151.3	21.2*	20.5*	50.6*‡§	243.6	59.8	7.3*	9.3*‡	23.6*‡§
Proteins	g	38.8	0.2*	5.1*‡	5.9*‡§	50.1	75.7	0.5*	11.0*‡	12.8*‡§
Total fats	g	20.1	18.4*	7.6*‡	10.5*‡§	56.6	42.2	23.8*	14.6*‡	19.5*‡§
Saturated fats	g	6.7	3.4*	3.2*‡	3.7*‡§	17.0	43.1	17.3*	18.4*‡	21.2*‡§
Fiber	g	8.0	0.0*	0.5*‡	0.8*‡§	9.3	82.0	0.2*	5.8*‡	12.0*‡§
Cholesterol	mg	183.8	6.1*	11.0*‡	14.5*‡§	215.5	80.3	3.2*	7.6*‡	8.9*‡§
Vitamin A	mcg	237.5	16.0*	28.1*‡	29.6*‡	311.2	77.3	0.1*	7.7*‡	10.1*‡§
Vitamin C	mg	54.7	0.1*	1.7*‡	12.0*‡§	68.5	80.5	0.4*	2.4*‡	16.7*‡§
Calcium	mg	656.9	10.9*	60.4*‡	68.5*‡§	796.8	80.4	1.6*	8.3*‡	9.7*‡§
Iron	mg	8.8	0.1*	0.9*‡	1.5*‡§	11.4	74.4	1.3*	9.3*‡	15.0*‡§
Magnesium	mg	301.1	3.6*	14.2*‡	28.8*‡§	347.7	82.6	1.1*	5.5*‡	10.9*‡§
Potassium	mg	1 634.6	39.8*	58.4*‡	184.0*‡§	1 918.9	83.3	1.9*	3.9*‡	10.9*‡§
Zinc	mg	5.6	0.0*	0.2*‡	0.9*‡§	6.8	80.1	0.4*	4.0*‡	15.5*‡§
Sodium	mg	198.9	1 409.3*	530.3*‡	496.1*‡§	2 634.6	20.2	13.9*	34.6*‡	31.4*‡§

* Significant difference from natural foods
‡ Significant difference from PCI
§ Significant difference from P foods. Superscripts mean that 95% confidence intervals (estimated through Taylor series linearization method) do not overlap

N: natural and minimally processed; PCI: processed culinary ingredients; P: processed; UP: ultra-processed. Food 1: grams of all foods and beverages in the Engasto database, including those without nutritional information. Food 2: grams of food with estimated nutrient content. With exception of Food 1, all estimates are based on the food and beverages with nutrient content

syrups, chocolate, sugar-based products, dressing and sauces, products related to food preparation, baby food, and alcoholic beverages. Respect to the total amount (expressed as g/day/adult equivalent) of each food group, the proportion of food and beverages whose nutritional content was not estimated was of 2.24% for natural foods, 7.94% for processed foods, and 1.18% for ultra-processed ones (table I).

Sociodemographic household covariates were evaluated, including the following characteristics of the household head: sex, age, indigenous language spoken, and education. The last was categorized into four groups: elementary (non-attendance to school, kindergarten, and elementary), junior high school (including equivalent technical careers), high school (including equivalent technical careers), and bachelor or postgraduate (including specialties, masters and doctoral degrees). The Latin American and Caribbean Scale of Food Security (ELCSA by its acronym in Spanish: *Escala Latinoamericana y Caribeña de Seguridad Alimentaria*)[27] was included in the Engasto. Because not all households had minors, we restricted our analysis to the six (of the twelve) items related to households and adults' experiences. Four groups were created according to the number of affirmative answers on the ELCSA: food secure (no affirmative answers), mild food insecure (one affirmative answer), moderate food insecure (two to three affirmative answers), and severe food insecure (four to six affirmative answers). With these cut-off points,[27,28] we sought the correspondence of item content with the food insecurity conceptualization. Region (North, West, Center, and South) and locality size (inhabitants in city: >100 000, urban: 15 000 to 99 999, semi-rural: 2 500 to 14 999 and rural: <2 500) were also evaluated.

Statistical analysis was conducted using the survey commands of the Stata software version 15.0.* These commands allow consideration of the complex design of the Engasto (i.e., strata, clustering, and weights).

* StataCorp, College Station, TX.

Table II
SOCIODEMOGRAPHIC CHARACTERISTICS OF MEXICAN HOUSEHOLDS IN 2013

	n	*N*	%	*CI*
HH sex				
Male	41 622	22 215 282	75.1	74.2-75.9
Female	15 061	7 378 870	24.9	24.1-25.8
HH age, years				
34 or younger	11 722	6 160 664	20.8	20.0-21.7
35 – 49	20 369	10 585 637	35.8	34.9-36.6
50 – 64	15 432	7 992 189	27.0	26.2-27.9
65 or older	9 160	4 855 662	16.4	15.7-17.1
HH education				
Elementary	21 862	12 397 486	41.9	40.5-43.3
Junior high school	14 528	7 538 075	25.5	24.7-26.3
High school	9 213	4 606 459	15.6	14.9-16.2
Bachelor or postgraduate	11 080	5 052 132	17.1	16.0-18.2
Food insecurity				
Food secure	36 930	17 615 913	59.5	58.2-60.9
Mild food insecure	7 115	4 159 739	14.1	13.3-14.8
Moderate food insecure	7 772	4 453 654	15.0	14.4-15.7
Severe food insecure	6 184	3 364 846	11.4	10.7-12.0
Geographic region				
North	16 109	7 098 354	24.0	21.9-26.2
West	15 172	6 687 442	22.6	20.2-25.2
Center	11 109	9 086 270	30.7	27.8-33.8
South	14 293	6 722 086	22.7	19.8-26.0
Locality size				
Cities	30 570	14 916 312	50.4	47.7-53.1
Urban	11 703	4 264 930	14.4	12.4-16.7
Semi-rural	6 440	4 089 691	13.8	12.1-15.7
Rural	7 970	6 323 219	21.4	19.1-23.8

HH: household head; n: sample; N: weighted estimations; CI: 95% confidence interval for proportions

Frequencies of categorical variables and means of continuous variables were estimated. To compare means between groups, the respective confidence intervals (95%) were calculated. Finally, linear regression models were estimated with the contribution of each food group to total energy as outcomes and sociodemographic household characteristics as covariates (i.e., age, sex and education of household head; food security; and geographical region and locality size).

Results

The distribution of households according to sociodemographic characteristics is presented in table II. Most of the household heads were male, one-third of them were between 35 and 49 years old, and almost half had elementary education or less. Half of the households were classified as food secure, a third of them belonged to the Center region, and half belonged to the cities.

Most of the foods available in the Mexican households were natural, followed by ultra-processed, processed, and processed culinary ingredients (table I). Therefore, contribution of natural foods to the energy and nutrients supply of households was higher than processed culinary ingredients and processed and ultra-processed foods. The only exception was sodium, which principal source were processed foods, followed by ultra-processed foods, natural foods and processed culinary ingredients. Processed culinary ingredients was the group which contributed with less households' supply of most nutrients, except total fats.

The nutritional characteristics (expressed as macronutrient distribution and nutrient density) of each food group are presented in table III. Processed culinary ingredients had the highest energy density; whereas natural foods had the lowest one. Natural and ultra-processed foods had higher relative content of carbohydrates than processed culinary ingredients and processed foods. Natural foods had the highest percentage of calories from proteins. Processed culinary ingredients had more energy from total fats, followed by processed food, ultra-processed foods and natural foods. Processed culinary ingredients and processed foods had more energy from saturated fats than the other groups. Natural foods had the highest density of fiber, cholesterol, vitamin A, vitamin C, calcium, iron, magnesium, potassium, and zinc, but the lowest sodium density. Processed culinary ingredients had the lowest density of fiber, vitamin C, calcium, iron, magnesium, and zinc. Processed foods had the lowest density of potassium. And ultra-processed foods had the lowest density of cholesterol and vitamin A.

Energy content of specific ultra-processed foods and the percentage contribution to total energy and to energy from the ultra-processed foods groups are presented in table IV. Sugar-sweetened beverages and fast food provided 56.2% of ultra-processed food energy and 13.1% of total energy. Packaged cereals contributed with 14.7% of ultra-processed food energy and 3.4% of

Table III
Macronutrient distribution and nutrient density of food groups in Mexican households, 2013

	Natural	*PCI*	*Processed*	*UP*	*Total*
	M	*M*	*M*	*M*	*M*
Energy density (kcal/g)	0.9	5.1*	2.8*,‡	1.5*,‡,§	1.2
Macronutrients (% of calories)					
Carbohydrates	62.5	34.9*	44.4*,‡	61.4‡,§	56.8
Proteins	17.4	1.4*	14.9*,‡	7.8*,‡,§	11.9
Total fats	21.2	64.7*	40.6*,‡	29.9*,‡,§	29.8
Saturated fats	7.4	18.0*	17.6*	10.6*,‡,§	9.4
Micronutrients (units/1 000 kcal)					
Cholesterol (mg)	236.5	71.3*	79.5*,‡	51.2*,‡,§	137.9
Fiber (g)	8.8	0.7*	3.3*,‡	2.5*,‡,§	5.4
Vitamin A (µg)	295.7	216.1*	207.0*	79.3*,‡,§	198.5
Vitamin C (mg)	70.3	4.9*	13.6*,‡	34.4*,‡,§	43.1
Calcium (mg)	735.0	98.4*	450.2*,‡	186.8*,‡,§	465.6
Iron (mg)	9.6	1.3*	6.1*,‡	4.5*,‡,§	6.7
Magnesium (mg)	313.9	56.0*	80.5*,‡	89.4*,‡,§	198.3
Potassium (mg)	1 851.9	624.7*	407.1*,‡	560.7*,‡,§	1 133.8
Zinc (mg)	6.0	0.3*	1.7*,‡	2.8*,‡,§	3.9
Sodium (mg)	242.5	11 998.4*	3 183.0*,‡	2 257.0*,‡,§	1 647.0

* Significant difference from natural foods
‡ Significant difference from PCI
§ Significant difference from processed foods

PIC: processed culinary ingredients
UP: ultra-processed

Table IV
RELATIVE AND ABSOLUTE VALUES OF ENERGY SUPPLY FROM ULTRA-PROCESSED SUB-FOOD GROUPS IN MEXICAN HOUSEHOLDS, 2013

	Kcal/day		*% of total energy*		*% of energy from ultra-processed foods*	
	M	*CI*	*M*	*CI*	*M*	*CI*
Sweetened beverages	106.0	102.6-109.5	8.5	8.4-8.7	36.4	35.8-37.1
Fast food	55.5	53.5-57.2	4.6	4.5-4.8	19.8	19.2-20.4
Packaged cereals	55.6	52.9-58.1	3.4	3.3-3.5	14.7	14.1-15.2
Biscuits and cookies	39.3	37.7-41.0	2.7	2.6-2.9	11.7	11.1-12.2
Sweets and candies	15.9	15.0-16.8	1.0	1.0-1.1	4.4	4.2-4.6
Oils	16.0	14.9-16.9	0.9	0.9-1.0	3.9	3.7-4.1
French fries and snacks	15.4	14.6-16.2	0.9	0.8-0.9	3.7	3.6-3.9
Milk and yogurt	14.4	12.6-15.7	0.8	0.8-0.9	3.5	3.3-3.7
Alcoholic beverages	2.9	1.6-4.3	0.1	0.1-0.1	0.4	0.3-0.6
Texturized soybean	1.3	1.1-1.4	0.1	0.1-0.1	0.5	0.5.-0.6
Sauces	1.1	1.0-1.2	0.1	0.1-0.1	0.3	0.3-0.4
Total	323.5	316.1-334.0	21.2	20.7-21.7	100.0	

M: mean; CI: 95% confidence intervals (estimated through Taylor series linearization method)

total energy. Alcoholic beverages, sauces, and soybeans were the items with the lowest availability and therefore contributed with less energy.

The association of sociodemographic household characteristics with food groups' contribution to total energy supply is presented in table V. Natural foods supply was higher in households headed by older people or with elementary education, those with any level of food insecurity, and those located in semi-rural or rural communities or in the South, West, and Center regions. The supply of processed culinary ingredients was higher in households headed by people from 35 to 65 years or who had elementary education, those with any level of food insecurity, households belonging to the West or South Regions and those located in urban, semi-rural or rural localities. Processed foods supply was higher in households headed by males, from 50 to 65 years or with junior high school education or more, households with food security, from West, Center or South regions or located in cities. The availability of ultra-processed foods was higher in households headed by people of 34 years or younger or those with higher education as well as in households with food security or located in the Northern region and cities.

Discussion

Our study showed that the availability of natural and processed foods is higher than ultra-processed foods in Mexico. Compared to the other groups, natural foods had the lowest energy density, were the main source and had the highest density of most micronutrients (except sodium), and high relative content of proteins and carbohydrates. Processed culinary ingredients had the highest energy density and the higher relative content of total and saturated fats. Processed foods had high relative content of saturated fats and were the main source of sodium. Ultra-processed foods were the second source of sodium and have high content of carbohydrates as percentage of total energy. The most common ultra-processed foods were sweetened beverages, fast food, packaged cereals and biscuits and cookies. The availability of ultra-processed foods was higher in households headed by younger people or with higher education, and in households with food security, from cities or from the Northern region. In most cases, the same trend was observed for processed foods. Whereas natural foods and processed culinary ingredients were more available in household headed by older people, with elementary

Table V
Linear regression models having as outcome the food groups contribution (as percentage) to total energy and as covariates the Mexican households' sociodemographic characteristics in 2013

	Natural		*PCI*		*Processed*		*Ultra-processed*	
	Mean	β	*Mean*	β	*Mean*	β	*Mean*	β
HH sex								
Male	54.7		12.8		11.1		21.5	
Female	56.1	0.42	12.9	0.03	10.6	-0.59*	20.5	0.13
HH age, years								
34 or younger	50.3		11.5		10.9		27.3	
35 – 49	54.0	3.38‡	12.5	1.01‡	11.0	0.11	22.5	-4.5‡
50 – 64	56.9	5.60‡	13.4	1.89‡	11.2	0.64§	18.5	-8.13‡
65 or older	60.1	6.70‡	14.1	1.66‡	10.6	1.08*	15.2	-9.45‡
HH education								
Elementary	60.4		14.9		9.2		15.5	
Junior high school	54.1	-3.08‡	12.8	-0.67§	11.1	1.49‡	22.0	2.26‡
High school	50.6	-5.51‡	11.0	-1.77‡	12.4	2.30‡	26.1	4.98‡
Bachelor or more	47.2	-8.26‡	9.1	-3.20‡	13.8	3.44‡	29.9	8.02‡
Food insecurity								
Food secure	52.3		11.6		11.9		24.2	
Mild food insecure	58.8	3.40‡	14.5	1.55‡	9.7	-1.17‡	17.0	-3.77‡
Moderate insecure	59.4	3.88‡	14.5	1.53‡	9.7	-1.28‡	16.4	-4.12‡
Severe food insecure	58.6	2.93‡	14.8	1.71‡	9.3	-1.43‡	17.3	-3.21‡
Geographic region								
North	51.1		11.5		8.3		29.2	
West	54.8	2.03‡	13.4	0.82*	11.4	4.05‡	20.4	-6.89‡
Center	55.2	3.12‡	12.2	0.17	14.1	6.20‡	18.6	-9.49‡
South	59.2	4.95‡	14.5	0.99§	9.1	2.47‡	17.2	-8.41‡
Locality size								
Cities	51.8		10.7		12.4		25.1	
Urban	53.7	0.58	12.9	1.78‡	11.3	-0.85*	22.1	-1.51*
Semi-rural	57.9	3.33‡	14.4	2.78‡	10.4	-1.66‡	17.3	-4.44‡
Rural	61.5	5.59‡	16.7	4.56‡	7.7	-3.34‡	14.0	-6.80‡

* $p < 0.010$
‡ $p < 0.001$
§ $p < 0.050$

HH: household head; β: linear regression coefficient
The reference groups were: men, 34 years old or younger, elementary, food secure, north regions, and cities

PIC: processed culinary ingredients

education, and household who experienced any level of food insecurity, located in the West, Center or South region, and in semi-rural or rural localities.

In the American region, as well as worldwide, ultra-processed food sales are related to the income level of the country;[5,6] sales are higher in high-income countries (e.g., Canada or United States of America), followed by middle-income countries (e.g., Mexico, Chile or Uruguay), and lower in low-income countries (e.g., Peru or Ecuador). However, the increase in ultra-processed foods sales has been higher in low- and middle-income countries than in high-income ones. These findings are

consistent with our results because ultra-processed food supply was the second group with more availability in Mexican households, but natural foods remain the first. In addition, the contribution of ultra-processed foods to total energy supply in Mexico (325.5 kcal, equivalent to 21.2% of total energy) is closer to the estimations for Brazil (423.4 kcal, 21.5%),[3] but lower than Canada (984.3 kcal, 47.7%)[13] and the United States of America (1 209.8 kcal, 57.9%).[14] These findings seem to imply that although ultra-processed food sales have increased in Mexico, there is still the possibility of preventing them from becoming predominant in the Mexican diet.

The items considered as ultra-processed foods are heterogeneous, and there are differences among countries. Therefore, the identification of specific ultra-processed foods with higher availability in each society can inform the design of strategies to control or mitigate their negative effects. The three ultra-processed foods that contributed with more energy to the diet in Brazil were cakes, tarts and cookies, fast food dishes, and sugar-sweetened beverages;[3] in Canada, they were soft drinks, fruit drinks and fruit juices, mass-produced packaged breads, and confectioneries;[13] and in the United States of America, they were breads, cakes, cookies and pies, and salty snacks.[14] In Mexico, the most important ultra-processed foods were sugar-sweetened beverages, fast food, packaged cereals, and biscuits and candies. The last result is congruent with the increasing consumption of sweetened beverages and alcohol by Mexican adolescents and adult women.[29] Recent analysis found that at the individual level, cookies, pastries and sweet bread were the most consumed ultra-processed food group by Mexicans, followed by sweetened beverages.[15] Sweetened beverages were the first main group available at the household level, which could be because people acquire this kind of beverages to consume in their house and share them with other households' members. In the case of cookies, pastries and sweet bread, they were the most consumed foods at the individual level, which could reflect the fact that people do not consume these foods at their home, but only buy and eat them away home.

These findings also give additional support to the recently implemented regulation of high-energy density foods and beverages sales through taxation in Mexico. This action contributed to the reduction of sugar-sweetened beverage purchases by 12% during a two-year period. This reduction was more notable among low socioeconomic households.[30] However, no measures have been implemented to reduce availability and/or accessibility to other ultra-processed foods. Policies could be guided by these findings to design specific approaches to regulate or reduce each food group consumption or supply in households or away from homes. For example, according to our analysis, fast foods are an important category of ultra-processed foods; however, more research is needed about their commercialization channels as well as their impact on health.

The natural foods available in Mexican households had lower content of saturated fats and sodium; but higher content of carbohydrates, protein, total fats, cholesterol, and other micronutrients. In Brazil[3] and Canada,[13] natural foods also contributed with more protein and micronutrients supply. In contrast, our analysis showed that ultra-processed foods were a main source of sodium and high content of carbohydrates, but low of vitamin A. In Brazil,[3] ultra-processed foods contributed more free sugars, total fats, saturated fats, and trans fats. In Canada,[13] ultra-processed foods contributed more carbohydrates, free sugars, and total fats. In other words, our results confirm that natural foods have better nutritional quality, and although the composition of ultra-processed foods varies among countries, they tend to have low nutritional quality.

The nutritional profile of processed culinary ingredients and processed foods should be motive of concern because they were an important source of sodium, and had high content of energy, total fats, and saturated fats; but low content of vitamin C, magnesium and zinc. Even this kind of foods can have higher content of energy, total fats, saturated fats, and sodium than ultra-processed foods. Production and commercialization's regulation of processed culinary ingredients and processed foods is challenging because some of them are staple foods (e.g. vegetable oil or sugar). As previous research[31] and our findings have showed, these foods are an important part of diet of low-income populations. A possible strategy is to make more affordable healthy foods and beverages as a previous step to implement some restriction to availability or access to processed culinary ingredients and processed foods.

In Mexico, ultra-processed foods are more available in households headed by younger people with higher education, in those with food security, or those from cities or the Northern region, such as shown in previous analysis of individual consumption.[13] On the other hand, natural and processed culinary ingredients foods were more available in households headed by older people or with lower education or with any level of food insecurity. Additionally, natural items were more available in households from the Southern region or rural communities. These patterns suggest that the acquisition of ultra-processed foods is more frequent among social groups that have a *modern* or *western* life-style because it is linked to urbanization, higher socioeconomic position, younger populations, and the proximity to the

United States of America. In contrast, the acquisition of natural foods (and to a lesser extent, processed foods) could be part of a *traditional* life-style associated with rural areas, impoverished sectors of society and older people. Mexican children with a western diet pattern have more odds to being overweight or obese than those with a traditional or rural diet pattern.[32]

Regarding socioeconomic differences, it is interesting to note that in Canada[13] the consumption of ultra-processed foods is higher among people with less education and households from rural areas. In contrast, in Mexico, there was higher availability of these items in households headed by people with higher education or from cities. These differences can be due to the higher production, availability, and affordability of natural foods in Mexico,[33] causing low-income households or those from rural localities to have greater access to them.

This study presents inherent limitations from the analysis of household expenditure surveys.[17,18] Food supply may have been underestimated by changes in household habits, types of food purchased within the reference period (i.e., perishable food can be bought in higher quantities), inaccuracy of reported food weights, lack of information about food consumed away from home, and the variability of the people who ate at home. In addition, the Engasto is a cross-sectional survey, which does not allow causal conclusions to be drawn, and was not designed with the main goal to distinguish differences between foods according to their processing level, therefore, misclassification of foods could exist because gross classifications were used (e.g., one category was salty cookies, but there was not a detailed description of this item; therefore, it was assumed to be an ultra-processed item). The proportion of processed foods that could not be considered to estimate their nutrient content was higher compared to the other food groups. Therefore, our results are an underestimation of the contribution of processed food to the nutrient availability in Mexican households. Finally, the national food composition reference did not have information about sugar content, and this precludes us to make comparisons with other studies.

In summary, our analysis showed that natural foods are the main source of energy in the Mexican diet, followed by ultra-processed foods, processed culinary ingredients, and processed foods. Natural foods are still the main source of protein, fiber, saturated fats, cholesterol, and most micronutrients. Processed culinary ingredients and processed foods were high in energy, total fats, and saturated fat; but had low content of certain micronutrients; whereas, ultra-processed foods contribute significantly to sodium supply. Ultra-processed food sub-groups that contribute with more energy to the diet are sugar-sweetened beverages, fast foods, packaged cereals, and biscuits and cookies. The household availability of ultra-processed foods is higher among the groups with better socioeconomic position and from more affluent areas (i.e. cities and North region), while natural foods and processed culinary ingredients availability is higher in low-income families and those from rural areas or impoverished regions. These findings can be used to guide efforts to promote healthy eating in Mexico. Until now, most regulations in Mexico have focused on ultra-processed foods. However, our results show that regulate the availability of processed culinary ingredients and processed foods is required because its nutritional quality could be poor.

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

References

1. Monteiro C, Cannon G, Levy R, Jean-Claude M, Jaime P, Martins AP, *et al*. Nova. The star shines bright. World Nutrition. 2016;7(1-3):28-38.
2. Moubarac JC, Martins AP, Claro RM, Levy RB, Cannon G, Monteiro CA. Consumption of ultra-processed foods and likely impact on human health. Evidence from Canada. Public Health Nutr. 2013;16(12):2240-8. https://doi.org/10.1017/S1368980012005009
3. Costa-Louzada ML, Martins AP, Canella DS, Baraldi LG, Levy RB, Claro RM, *et al*. Ultra-processed foods and the nutritional dietary profile in Brazil. Rev Saude Publ. 2015;49:38. https://doi.org/10.1590/S0034-8910.2015049006132
4. Popkin BM, Adair LS, Ng SW. Global nutrition transition and the pandemic of obesity in developing countries. Nutr Rev. 2012;70(1):3-21. https://doi.org/10.1111/j.1753-4887.2011.00456.x
5. Organización Panamericana de la Salud, Organización Mundial de la Salud. Alimentos y bebidas ultraprocesados en América Latina: tendencias, efecto sobre la obesidad e implicaciones para las políticas públicas. Washington DC: OPS, 2015.
6. Monteiro CA, Moubarac JC, Cannon G, Ng SW, Popkin B. Ultra-processed products are becoming dominant in the global food system. Obes Rev. 2013;14(suppl 2):21-8. https://doi.org/10.1111/obr.12107
7. Ares G, Vidal L, Allegue G, Gimenez A, Bandeira E, Moratorio X, *et al*. Consumers' conceptualization of ultra-processed foods. Appetite. 2016;105:611-7. https://doi.org/10.1016/j.appet.2016.06.028
8. Rauber F, Campagnolo PD, Hoffman DJ, Vitolo MR. Consumption of ultra-processed food products and its effects on children's lipid profiles: a longitudinal study. Nutr Metab Cardiovasc Dis. 2015;25(1):116-22. https://doi.org/10.1016/j.numecd.2014.08.001
9. Louzada ML, Baraldi LG, Steele EM, Martins AP, Canella DS, Moubarac JC, *et al*. Consumption of ultra-processed foods and obesity in Brazilian adolescents and adults. Prev Med. 2015;81:9-15. https://doi.org/10.1016/j.ypmed.2015.07.018
10. Mendonca RD, Pimenta AM, Gea A, de la Fuente-Arrillaga C, Martinez-Gonzalez MA, Lopes AC, *et al*. Ultra processed food consumption and risk of overweight and obesity: the University of Navarra Follow-Up (SUN) cohort study. Am J Clin Nutr. 2016;104(5):1433-40.
11. Mendonca RD, Lopes AC, Pimenta AM, Gea A, Martinez-Gonzalez MA, Bes-Rastrollo M. Ultra-processed food consumption and the incidence of hypertension in a mediterranean cohort: The Seguimiento Universidad de Navarra Project. Am J Hypertens. 2016. https://doi.org/10.3945/ajcn.116.135004

12. Tavares LF, Fonseca SC, Garcia Rosa ML, Yokoo EM. Relationship between ultra-processed foods and metabolic syndrome in adolescents from a Brazilian Family Doctor Program. Public Health Nutr. 2012;15(1):82-7. https://doi.org/10.1017/S1368980011001571
13. Moubarac JC, Batal M, Louzada ML, Martinez-Steele E, Monteiro CA. Consumption of ultra-processed foods predicts diet quality in Canada. Appetite. 2016;108:512-20. https://doi.org/10.1016/j.appet.2016.11.006
14. Martínez-Steele E, Baraldi LG, Louzada ML, Jean-Claude M, Dariush M, Augusto C. Ultra-processes foods and added sugars in the US diet: evidence from a nationally representative cross-sectional study. BMJ Open. 2016;6:e009892. https://doi.org/10.1136/bmjopen-2015-009892
15. Marron-Ponce JA, Sanchez-Pimienta TG, Louzada M, Batis C. Energy contribution of Nova food groups and sociodemographic determinants of ultra-processed food consumption in the Mexican population. Public Health Nutr. 2018;21(1):87-93. https://doi.org/10.1017/S1368980017002129
16. Instituto Nacional de Estadística y Geografía. Encuesta Nacional de Gastos de los Hogares 2013: Engasto. Diseño muestral: formación de las unidades primarias de muestreo para el levantamiento. Aguascalientes, México: INEGI, 2013.
17. Smith LC, Subandoro A. Measuring food security using household expenditure surveys. Washington DC: International Food Policy Research Institute, 2007.
18. Fiedler JL, Lividini K, Bermudez OI, Smitz MF. Household consumption and expenditures surveys (HCES): a primer for food and nutrition analysts in low- and middle-income countries. Food Nutr Bull. 2012;33(suppl 3):S170-84. https://doi.org/0.1177/15648265120333S205
19. Charrondiere UR, Haytowitz D, Stadlmayr B. FAO / INFOODS density database version 2.0. Rome, Italy: FAO, 2012.
20. Teruel G, Rubalcava L, Santana A. Escalas de equivalencia para México. Mexico: Secretaría de Desarrollo Social, 2005.
21. Joint WHO/FAO Expert Consultation on Diet, Nutrition and the Prevention of Chronic Diseases. Diet, nutrition and the prevention of chronic diseases: Report of a Joint WHO/FAO expert consultation. Geneva, Switzerland: WHO, 2002.
22. Instituto Nacional de Estadística y Geografía [internet]. Aguascalientes: INEGI; c2018. Principales causas de mortalidad por residencia habitual, grupos de edad y sexo del fallecido Estados Unidos Mexicanos [cited July 31, 207]. Available from: http://www.inegi.org.mx/est/contenidos/proyectos/registros/vitales/mortalidad/tabulados/ConsultaMortalidad.asp
23. Organización Mundial de la Salud. Obesidad y sobrepeso. Ginebra: OMS, 2018 [cited March 8, 2018]. Available from: https://www.who.int/es/news-room/fact–sheets/detail/obesity–and–overweight
24. Gutiérrez JP, Rivera-Dommarco J, Shamah-Levy T, Villalpando-Hernández S, Franco A, Cuevas-Nasu L, *et al*. Encuesta Nacional de Salud y Nutrición 2012. Resultados Nacionales. Cuernavaca, México: Instituto Nacional de Salud Pública, 2012.
25. Muñoz M, Ledesma JA, Chávez A. Composición de alimentos. Valor nutritivo de los alimentos de mayor consumo. Ciudad de México: McGraw Hill Interamericana, 2010.
26. United States Department of Agriculture [internet]. USDA Food Composition Databases 2016 [cited February 6, 2016]. Available from: https://ndb.nal.usda.gov/ndb/search/list
27. Pérez-Escamilla R, Segall-Correa AM, Álvarez MC, Melgar-Quiñonez H. Escala Latinoamericana y Caribeña de Seguridad Alimentaria (ELCSA): Manual de uso y aplicaciones. Roma: FAO, 2012.
28. Barquera S, Campos I, Hernández L, Rivera J. Obesidad en adultos: los retos de la cuesta abajo. In: Encuesta Nacional de Salud y Nutrición 2012. Evidencia para la política púbica en salud. Cuernavaca, México: INSP, 2012.
29. Barquera S, Campos-Nonato I, Rojas R, Rivera J. Obesidad en México: epidemiología y políticas de salud para su control y prevención. Gac Med Mex. 2010;146:397-407.
30. Colchero MA, Popkin BM, Rivera JA, Ng SW. Beverage purchases from stores in Mexico under the excise tax on sugar sweetened beverages: observational study. BMJ. 2016;352:h6704. https://doi.org/10.1136/bmj.h6704
31. Valencia-Valero RG, Ortiz-Hernández L. Disponibilidad de alimentos en los hogares mexicanos de acuerdo con el grado de inseguridad alimentaria. Salud Publica Mex. 2014;56(2):154-64. https://doi.org/10.21149/spm.v56i2.7331
32. Rodriguez-Ramirez S, Mundo-Rosas V, Garcia-Guerra A, Shamah-Levy T. Dietary patterns are associated with overweight and obesity in Mexican school-age children. Arch Latinoam Nutr. 2011;61(3):270-8.
33. Ortiz-Hernández L. Evolución de los precios de los alimentos y nutrimentos en México entre 1973 y 2004. Arch Latinoam Nut. 2006;56(3):16.