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# Ultra-processed foods and the nutritional dietary profile in Brazil

## Alimentos ultraprocessados e perfil nutricional da dieta no Brasil

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### ABSTRACT

**OBJECTIVE:** To assess the impact of consuming ultra-processed foods on the nutritional dietary profile in Brazil.

**METHODS:** Cross-sectional study conducted with data from the module on individual food consumption from the 2008-2009 *Pesquisa de Orçamentos Familiares* (POF – Brazilian Family Budgets Survey). The sample, which represented the section of the Brazilian population aged 10 years or over, involved 32,898 individuals. Food consumption was evaluated by two 24-hour food records. The consumed food items were classified into three groups: natural or minimally processed, including culinary preparations with these foods used as a base; processed; and ultra-processed.

**RESULTS:** The average daily energy consumption *per capita* was 1,866 kcal, with 69.5% being provided by natural or minimally processed foods, 9.0% by processed foods and 21.5% by ultra-processed food. The nutritional profile of the fraction of ultra-processed food consumption showed higher energy density, higher overall fat content, higher saturated and trans fat, higher levels of free sugar and less fiber, protein, sodium and potassium, when compared to the fraction of consumption related to natural or minimally processed foods. Ultra-processed foods presented generally unfavorable characteristics when compared to processed foods. Greater inclusion of ultra-processed foods in the diet resulted in a general deterioration in the dietary nutritional profile. The indicators of the nutritional dietary profile of Brazilians who consumed less ultra-processed foods, with the exception of sodium, are the stratum of the population closer to international recommendations for a healthy diet.

**CONCLUSIONS:** The results from this study highlight the damage to health that is arising based on the observed trend in Brazil of replacing traditional meals, based on natural or minimally processed foods, with ultra-processed foods. These results also support the recommendation of avoiding the consumption of these kinds of foods.

**DESCRIPTORS:** Food Consumption. Industrialized Foods. Nutritive Value. Food Quality. Nutritional Epidemiology.

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## RESUMO

**OBJETIVO:** Avaliar o impacto do consumo de alimentos ultraprocessados sobre o perfil nutricional da dieta.

**MÉTODOS:** Estudo transversal com dados obtidos do módulo sobre consumo alimentar de indivíduos da Pesquisa de Orçamentos Familiares 2008-2009. A amostra, representativa da população brasileira de 10 ou mais anos de idade, envolveu 32.898 indivíduos. O consumo alimentar foi avaliado por meio de dois registros alimentares de 24h. Os alimentos consumidos foram classificados em três grupos: *in natura* ou minimamente processados, incluindo preparações culinárias à base desses alimentos; processados; e ultraprocessados.

**RESULTADOS:** O consumo médio diário de energia *per capita* foi de 1.866 kcal, sendo 69,5% proveniente de alimentos: *in natura* ou minimamente processados, 9,0% de alimentos processados e 21,5% de alimentos ultraprocessados. O perfil nutricional da fração do consumo relativo a alimentos ultraprocessados mostrou maior densidade energética, maior teor de gorduras em geral, de gordura saturada, de gordura *trans* e de açúcar livre e menor teor de fibras, de proteínas, de sódio e de potássio, quando comparado à fração do consumo relativa a alimentos *in natura* ou minimamente processados. Alimentos ultraprocessados apresentaram, no geral, características desfavoráveis quando comparados aos alimentos processados. Maior participação de alimentos ultraprocessados na dieta determinou generalizada deterioração no perfil nutricional da alimentação. Os indicadores do perfil nutricional da dieta dos brasileiros que menos consumiram alimentos ultraprocessados, com exceção do sódio, aproximam este estrato da população das recomendações internacionais para uma alimentação saudável.

**CONCLUSÕES:** Os resultados indicam prejuízos à saúde decorrentes da tendência observada no Brasil de substituir refeições tradicionais baseadas em alimentos *in natura* ou minimamente processados por alimentos ultraprocessados e apoiam a recomendação para ser evitado o consumo desses alimentos.

**DESCRITORES:** Consumo de Alimentos. Alimentos Industrializados. Valor Nutritivo. Qualidade dos Alimentos. Epidemiologia Nutricional.

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## INTRODUCTION

Ultra-processed foods are ready-to-consume products that are made up entirely or mostly from substances extracted from food (oils, fats, sugar, proteins), derived from food constituents (hydrogenated fats, modified starches), or synthesized, based on organic materials (dyes, flavorings, flavor enhancers and other additives used to alter the food's sensory properties).<sup>11,12,15,16,18</sup>

Analysis of household budget surveys from three countries<sup>2,9,19</sup> and time series food sales statistics in 79 countries<sup>14</sup> indicate a general trend of increasing ultra-processed food consumption, being more acute in middle-income countries such as Brazil.

Studies that investigate household food purchases using data from household budget surveys, performed in Brazil, Canada and Chile, show that ultra-processed

foods averagely have higher energy density, higher free sugar content and less fiber than natural or minimally processed food, even when these foods are combined with culinary ingredients such as salt, sugar and fats.<sup>3,13,17</sup> We found no records of any studies that have linked ultra-processed foods to the nutritional dietary quality of what is actually consumed by individuals.

This study's objective was to evaluate the impact of ultra-processed food consumption on the nutritional dietary profile in Brazil.

## METHODS

The data analyzed during this study was taken from the *Pesquisa de Orçamentos Familiares* (POF – Brazilian Family Budgets Survey) performed by the Brazilian

Institute of Geography and Statistics (IBGE) between May 2008 and May 2009.<sup>5,6</sup>

The sample of households from the POF was extracted using a sampling plan by conglomerates with a census sector raffle in the first stage, and households, in the second. The census tracts were grouped prior to the raffle in strata with sufficient geographical and socio-economic homogeneity. The census tract raffle within each stratum was performed with a probability that was proportional to the number of households in each sector. During the second stage, within each tract, the households were selected by simple random sampling, without replacement. The sample was made up of 55,970 households.<sup>5</sup>

The search module relating to individual food consumption was applied in a random subsample of 13,569 households (24.3% of the total studied households). All residents from these households, aged 10 years or older, were selected. This sub-sample involved 34,003 individuals.

Food consumption was evaluated using two 24-hour food records, on non-consecutive days, in which the individuals recorded, using home measurements, the quantities and preparation methods of each consumed food. Eventually, the records were completed with the help from other household resident or complemented by interviews, in which the research agent would review the information filled in by the informant. The research agent then transcribed the information so it could be entered onto an electronic data system.

Data such as the respondent's date of birth, gender and household income *per capita* were obtained by standardized questionnaires. The data also included the urban or rural situation of the household and its location in term of one of Brazil's five macroregions (North, Northeast, Midwest, Southeast and South).

Food quantities were listed about grams or milliliters, based on the home measurement table used for food consumed in Brazil,<sup>7</sup> which was built from compiling home measurement tables and other information sources. Amounts deemed unlikely or whenever missing were imputed based on a similarity matrix. This matrix was formed based on variables that had been correlated with the quantity consumed variable (informant's gender, age, state, macro-region and informed measurement unit) using the hot deck technique.<sup>7</sup>

These food quantities were converted into kilocalories and into grams or milligrams of nutrients based on a table representing information regarding food consumption in Brazil.<sup>8</sup> This table was constructed based on data from the Brazilian Food Composition Table and a similar table from the United States

Department of Agriculture, in addition to regional recipes and food label references.<sup>8</sup>

In accordance with the guidelines provided by the IBGE,<sup>8</sup> added sugar content in fruit juices, coffee and tea was standardized in an amount equivalent to 10.0% of the consumed volume, whenever the individual reported to habitually add sugar to drinks; and 5.0% of the volume of added sugar and artificial sweeteners. A drink was considered to be without added sugar when the individual reported that they did not usually add sugar to their drinks.

The 1,120 reported consumption items were classified into three groups: natural or minimally processed foods, processed foods, and ultra-processed foods.<sup>11,15,18</sup>

The first group included foods that had been directly obtained from plants or animals (such as leaves, fruits, eggs and milk), those acquired for consumption without having undergone any alteration following their harvest (natural foods) and natural foods that, prior to having been acquired, were cleaned, had their inedible or unwanted parts removed, and had been subjected to drying, packing, pasteurization, freezing, refinement, fermentation and other processes that do not include substances being added to the original food (minimally processed foods). Culinary preparations based on one or more natural or minimally processed food items were included in this first group. These preparations were included when the food and all the other ingredients, including any other edible foods used in the final project such as salt, sugar, vinegar and oils, were used in the recipe.<sup>11,15,18</sup>

The second group is essentially made up of industrial products produced in which salt or sugar (and eventually oil or vinegar) had been added to a natural or minimally processed food, including canned vegetables, fruits in syrup, cheeses and breads made with flour, water, and salt (and yeast used to ferment the flour).<sup>11,15,18</sup>

The third group is composed of industrial products that are entirely or mostly made from substances extracted from food (oils, fats, sugar, proteins), those that are derived from food constituents (hydrogenated fats, modified starch) or foods synthesized in laboratory based on organic materials (colorants, flavorings, flavor enhancers and other additives used to give the products attractive sensory properties).<sup>11,15,18</sup> Ultra-processed foods include sweet and salty biscuits, chips, granola bars, confectionary in general, fast food dishes, instant noodles, various types of ready or semi-ready meals and soft drinks. The main characteristics of each food group and a detailed list of examples are presented in the Annex.

All analyses were conducted with individuals who had filled out records referring to two days of food consumption, which were conducted for 96.8% of the total number of individuals who participated in the search module regarding individual food consumption.

The study population's consumption pattern was described by distributing the total calories consumed by individuals, according to the three food groups used in this study, and internally within these groups, according to selected subgroups.

Individuals were classified into five strata according to the caloric value that ultra-processed foods contributed to the total value of their diet. These strata were related to the distribution quintiles of caloric contribution from ultra-processed food across the Brazilian population. The consumption pattern in each of these strata was described in a similar manner to what was used for the whole population.

The impact ultra-processed food consumption on diet quality took into account indicators for which the World Health Organization established recommendations for consumption, which are valid for the whole population, independent of gender, age and physiological state: protein, carbohydrates, free sugar, fiber, total fats, saturated fat, trans fat, fiber, sodium and potassium.<sup>30,34</sup> Indicators relating to fiber, sodium and potassium intake were expressed per 1,000 kcal, while other nutrients were expressed as a percentage of total calories ingested. Additionally, energy density from the solid fraction of the diet was included, which was calculated by dividing the sum of calories from solid food intake by the amount in grams of these foods. The recommendations used for this indicator were as proposed by the World Cancer Research Fund.<sup>29</sup>

Nutritional indicators were used to assess the quality of the average Brazilian diet. The averages from the nutritional indicators of the fraction of the diet, exclusively made up by ultra-processed foods, were compared to the fraction of the diet that only consisted of consumable items from the natural or minimally processed food group, and with the fraction of the diet that was restricted to processed foods. The Student's *t*-test was used for these comparisons.

The indicators were used to evaluate the dietary quality of the Brazilian population strata corresponding to the distribution quintiles of caloric contribution from ultra-processed foods to total calories. Linear regression analyses were used to identify the direction and the statistical significance of the association between the distribution quintiles of caloric contribution from ultra-processed foods and nutritional indicators, with and without fitting for confounding variables (household income, urban or rural residence, macro-region, age and gender).

All analyses were performed using Stata 13.0 software, considering the complex sample design.

This study was approved by the Research Ethics Committee from the Faculdade de Saúde Pública at the Universidade de São Paulo (Protocol 128,958, 10/19/2012).

## RESULTS

The average daily energy consumption for Brazilians aged ten years or over was 1,866 kcal, with 69.5% being by the consumption of natural or minimally processed food, 9.0% from processed foods and 21.5% from ultra-processed foods (Table 1).

When considered together, rice and beans are responsible for more than one quintile (22.9%) of the energy consumed throughout the day. Other natural or minimally processed foods, which are relevant to Brazilian food consumption, are red meats, fruits, other cereals (not rice) and milk, with each of them contributing at least 5.0% of total daily energy. Poultry, roots and tubers, coffee and tea, fish, vegetables and eggs contribute less to energy.

Among the processed foods, the largest contribution to total energy intake came from French bread (6.9% of daily calories), followed by cheese, processed meats and canned fruits and vegetables.

Among the ultra-processed foods are cakes, pies and cookies (3.0% of daily calories), fast food dishes (2.9%), sugar-sweetened beverages (2.6%), sliced loafs, hamburger and hot dog breads (2.4%) and confectionary (2.2%). Second in energy contribution, are crackers, chips, sausages, ready or semi-ready meals and sweetened dairy drinks.

The mean contribution from ultra-processed foods towards total consumed energy ranged from less than 2.0% in the first quintile to about 50.0% in the last quintile. The contribution from all categories of ultra-processed foods significantly increases from the first quintile to the last. An inverse tendency was observed for all natural or minimally processed foods, except for fruits and vegetables, which did not varied significantly. Significant, albeit not uniform, variations were observed in processed foods: cheese and canned fruits and vegetables represented increased consumption of ultra-processed foods, while the opposite was observed for French bread and processed meat. Thus, there is evidence to affirm that a mixed nature involved in the processed foods group exists, part to do with the varying pattern found in natural or minimally processed foods, and part to do with the varying pattern of ultra-processed foods (Table 2).

Table 3 shows the Brazilian diet evaluation (all ingested foods) and the relative food consumption fractions,

**Table 1.** Absolute and relative consumption averages of natural or minimally processed foods, processed foods and ultra-processed foods in the Brazilian population aged 10 years or over (2008-2009).

Food group and consumable items	Kcal/day	% of total energy intake
Natural or minimally processed foods (including culinary preparations using them as base)	1275.5	69.5
Rice	226.0	12.6
Beans	189.6	10.3
Beef or pork	188.7	10.0
Fruits <sup>a</sup>	132.7	7.0
Other cereals <sup>b</sup>	110.6	6.0
Milk	96.1	5.4
Poultry	88.1	4.9
Roots and tubers	78.0	3.9
Coffee and tea	47.7	2.9
Fish	33.2	1.7
Vegetables	21.7	1.4
Eggs	24.4	1.4
Other natural or minimally processed foods <sup>c</sup>	38.6	2.0
Processed foods	167.1	9.0
French bread	126.3	6.9
Cheeses	21.4	1.1
Processed meat	17.7	0.9
Canned fruits and vegetables	1.8	0.1
Ultra-processed foods	423.4	21.5
Cakes, pies and cookies	62.4	3.0
Fast food dishes <sup>d</sup>	55.9	2.9
Sugar-sweetened beverages	51.5	2.6
Sliced bread, hamburger, hot dog and similar baps	42.2	2.4
Confectionary <sup>e</sup>	47.8	2.2
Crackers and chips	39.9	2.0
Sausages	27.7	1.5
Ready or semi-ready meals <sup>f</sup>	55.9	1.7
Sweetened dairy drinks	31.7	1.6
Other ultra-processed foods <sup>g</sup>	29.2	1.5
Total	1866.0	100

<sup>a</sup> Including juices squeezed from fruit.

<sup>b</sup> Corn, oats and wheat and their flours and preparations such as couscous and pasta dishes

<sup>c</sup> Nuts and seeds, plain yogurt, preparations with a lentil base, peas, soy, seafood and preparations made with mixtures of various foods.

<sup>d</sup> Burgers of all kinds, hotdogs, fried and baked snacks or similar.

<sup>e</sup> Candies, chocolates, gelatin, flan and ice cream.

<sup>f</sup> Pizzas, frozen pasta or meat dishes, instant noodles and powdered soups.

<sup>g</sup> Margarine, processed sauces and breakfast cereals.

respectively, for natural or minimally processed foods, processed foods and ultra-processed foods.

The diet of the Brazilian population exceeds consumption recommendations for energy density, protein, free sugar, trans fat and sodium and is insufficient regarding fiber and potassium.

Compared to the fraction of the diet concerning natural or minimally processed food, the fraction referring to ultra-processed foods has 2.5 times more energy per gram, 2 times more free sugar, 1.5 times more overall and saturated fats and 8 times more trans fats, in addition to being lower in fiber (3 times less), proteins (2 times less) and potassium

**Table 2.** Distribution (%) of total energy intake according to food groups and consumption items in strata of the Brazilian population aged 10 years or over referring to quintiles of ultra-processed food consumption (2008-2009).

Food group and consumable items	Quintile of ultra-processed food consumption (% of total energy)				
	Q1	Q2	Q3	Q4	Q5
Natural or minimally processed foods and culinary preparations using them as base	87.8	79.9	72.4	62.7	44.9 <sup>h</sup>
Rice	17.1	14.6	13.0	10.8	7.8 <sup>h</sup>
Beans	14.7	12.0	10.8	8.7	5.7 <sup>h</sup>
Beef or pork	12.1	11.2	10.6	9.2	6.7 <sup>h</sup>
Fruit <sup>a</sup>	6.2	7.4	7.7	7.5	6.2
Other cereals <sup>b</sup>	7.5	7.0	6.0	5.5	4.0 <sup>h</sup>
Milk	5.4	5.9	5.9	5.6	4.1 <sup>h</sup>
Poultry	5.5	5.8	5.1	4.7	3.3 <sup>h</sup>
Roots and tubers	5.8	4.6	3.7	3.2	2.3 <sup>h</sup>
Coffee and tea	4.2	3.5	2.8	2.4	1.4 <sup>h</sup>
Fish	3.2	2.3	1.6	1.0	0.5 <sup>h</sup>
Vegetables	1.4	1.5	1.6	1.4	1.0
Eggs	2.0	1.7	1.4	1.2	0.7 <sup>h</sup>
Other foods, their preparations and mixed preparations <sup>c</sup>	2.7	2.3	2.1	1.7	1.2 <sup>h</sup>
Processed foods	10.4	10.5	9.7	8.5	5.8 <sup>h</sup>
French bread	8.1	8.4	7.6	6.4	4.2 <sup>h</sup>
Cheese	0.8	1.0	1.2	1.4	1.1 <sup>h</sup>
Processed meat	1.4	1.0	0.8	0.7	0.5 <sup>h</sup>
Canned fruits and vegetables	0.1	0.1	0.1	0.1	0.1 <sup>h</sup>
Ultra-processed foods	1.8	9.6	17.9	28.7	49.2 <sup>h</sup>
Cakes, tarts and cookies	0.2	1.2	2.1	3.9	7.5 <sup>h</sup>
Fast food dishes <sup>d</sup>	0.1	0.7	1.9	3.8	8.0 <sup>h</sup>
Sugar-sweetened beverages	0.4	1.5	2.7	3.7	5.0 <sup>h</sup>
Sliced bread, hamburger, hot dog and other processed breads	0.1	1.2	2.6	3.7	4.3 <sup>h</sup>
Confectionary <sup>e</sup>	0.1	0.6	1.3	2.9	6.0 <sup>h</sup>
Crackers and chips	0.3	1.4	2.1	2.4	4.0 <sup>h</sup>
Processed meats	0.2	0.9	1.6	2.1	2.5 <sup>h</sup>
Ready or semi-ready meals <sup>f</sup>	0.0	0.1	0.6	1.9	6.1 <sup>h</sup>
Sweetened dairy drinks	0.1	0.4	1.2	2.3	4.2 <sup>h</sup>
Other products <sup>g</sup>	0.4	1.6	2.0	2.0	1.7 <sup>h</sup>
Total	100	100	100	100	100

<sup>a,b,c,d,e,f,g,h</sup> See Table 1.

<sup>h</sup>  $p < 0.001$  for the linear tendency of the variation from the contribution of the item based on the quintiles of ultra-processed food consumption.

(2.5 times less) content. In comparison to processed foods, ultra-processed foods also have greater energy density, a higher content of free sugar, overall fats, saturated and trans fats and a lower protein and fiber content. Processed and ultra-processed foods have similar potassium contents. Processed foods have particularly high sodium contents: 2.5 g per 1,000 kcal compared with 1.4 g in ultra-processed foods and 1.7 g in minimally processed foods and their culinary preparations.

Table 4 presents indicators of the nutritional dietary profile for the five strata of the population corresponding to increasing quintiles in energy contribution from ultra-processed foods.

The energy density of the diet and the relative content of free sugar, general fats, saturated fats and trans fats increase significantly with the increase in the contribution of ultra-processed foods, while the opposite occurs for protein, fiber, potassium and sodium. Controlling

the household income, urban or rural residence, region, age and gender variables do not make any difference to these results.

In contrast with the Brazilian population's average diet, the diet of the quintile of individuals with lower relative consumption of ultra-processed food was in line with recommendations for fiber and trans fat consumption and close to recommendations for that of energy density, free sugar, and potassium (Table 3). The diet of the quintile of individuals with lower relative consumption of ultra-processed food is also suitable for consumption levels of total and saturated fats, which are nutrients that are excessively consumed by the quintile with higher relative consumption of ultra-processed foods. Sodium consumption in the diet exceeded the recommended amount (< 1 g/1,000 kcal) in all strata of the population.

## DISCUSSION

The results from this study confirm the negative nutritional profile of ultra-processed food and document their largely negative impact on food quality in the Brazilian population, particularly considering the increase of the diet's energy density, levels of sugar,

saturated and trans fat and the decreasing levels of fiber and potassium.

High energy density diets make it difficult for the human body to regulate energy balance, which increases the risk of excessive weight gain.<sup>24</sup> Excessive free sugar in the diet also increases the risk of excessive weight gain and obesity,<sup>28</sup> in addition to increasing the incidence of tooth decay.<sup>20</sup> Excessive saturated and trans fat content increase morbidity and mortality from cardiovascular diseases.<sup>21,32</sup> On the other hand, insufficient fiber intake increases the risk of obesity, diabetes, cardiovascular diseases and several types of cancer, such as colon, rectal, and breast,<sup>10,22,30</sup> while insufficient potassium intake increases the risk of high blood pressure.<sup>33</sup>

As the ultra-processed food category has only recently been defined, few population studies that have evaluated the association between their consumption and morbidity and mortality exist.<sup>11,12,15,16,18</sup> However, studies that have been performed in Brazil indicate the existence of significant associations between ultra-processed food consumption and metabolic syndrome in adolescents,<sup>27</sup> dyslipidemias in children<sup>23</sup> and obesity in all age groups.<sup>1</sup>

**Table 3.** Averages of nutritional indicators, from food consumption in the Brazilian population aged 10 years or over, and the fraction of this consumption referring to the groups containing *in natura* or minimally processed foods, processed foods and ultra-processed foods (2008-2009).

Indicator	Fraction of food consumption				Recommended values for the indicators
	Total food consumption	Natural or minimally processed food	Processed foods	Ultra-processed foods	
Total energy (kcal/d)	1866.0	1275.5	167.1	423.4 <sup>a</sup>	–
Percentage contribution to the total energy of:					
Protein	17.2	19.5	15.7	8.6 <sup>a</sup>	10-15 <sup>c</sup>
Carbohydrates	56.2	55.6	63.7	54.4 <sup>a</sup>	55-75 <sup>c</sup>
Free sugar	15.4	13.5	0.6	29.2 <sup>a</sup>	< 10 <sup>c</sup>
Fats	26.9	24.8	20.6	37.0 <sup>a</sup>	15-30 <sup>c</sup>
Saturated fat	9.4	8.4	9.5	12.0 <sup>a</sup>	< 10 <sup>c</sup>
Trans fat	1.4	0.6	1.2	5.0 <sup>a</sup>	< 1 <sup>c</sup>
Energy density (kcal/g) <sup>a</sup>	1.7	1.4	2.9	3.7 <sup>a</sup>	1.25-1.45 <sup>d</sup>
Fiber density (g/1,000 kcal)	11.1	13.4	6.5	4.5 <sup>a</sup>	> 12.5 <sup>b,e</sup>
Sodium density (g/1,000 kcal)	1.7	1.7	2.5	1.4 <sup>a</sup>	< 1 <sup>f</sup>
Potassium density (mg/1,000 kcal)	1275.4	1583.7	584.1	604.6 <sup>a</sup>	≥ 1,755 <sup>f</sup>

<sup>a</sup> Value significantly different ( $p < 0.05$ ) from the estimated value for *in natura* or minimally processed food and processed foods.

<sup>b</sup> Energy density only calculated for the solid fraction of the diet, referring to the sum of the calories from solid foods divided by the amount of these foods in grams.

<sup>c</sup> World Health Organization (WHO). Diet, nutrition and the prevention of chronic diseases. Geneva: World Health Organization; 2003.

<sup>d</sup> World Cancer Research Foundation (WCRF). Energy density: finding the balance for cancer prevention. London: World Cancer Research Foundation; 2009.

<sup>e</sup> Recommended value based on a 2,000 kcal diet.

<sup>f</sup> World Health Organization (WHO). World Health Organization issues new guidance on dietary salt and potassium. Geneva; 2013. Recommended value based on a 2,000 kcal diet.

**Table 4.** Averages of nutritional indicators from food consumption by strata of the Brazilian population aged 10 years or over, referring to quintiles of ultra-processed food consumption (2008-2009).

Indicador	Quintile of ultra-processed food consumption (% of total energy)				
	Q1	Q2	Q3	Q4	Q5
Total energy (kcal/d)	1707.9	1794.4	1841.0	1920.4	2066.8 <sup>b</sup>
Energy density (kcal/g) <sup>a</sup>	1.5	1.5	1.6	1.7	1.9 <sup>b</sup>
Percentage contribution to the total energy of:					
Protein	19.3	18.2	17.3	16.3	14.8 <sup>b</sup>
Carbohydrate	56.7	56.5	56.2	56.1	55.6 <sup>b</sup>
Free sugar	10.9	13.1	15.0	17.6	20.2 <sup>b</sup>
Total fat	23.8	25.4	26.8	28.1	30.4 <sup>b</sup>
Saturated fat	7.9	8.5	9.1	10.0	11.5 <sup>b</sup>
Trans fat	0.8	1.3	1.5	1.7	1.9 <sup>b</sup>
Nutrient density:					
Fiber (g/1,000 kcal)	13.0	11.9	11.3	10.3	8.9 <sup>b</sup>
Sodium (g/1,000 kcal)	1.9	1.8	1.7	1.7	1.6 <sup>b</sup>
Potassium (mg/1,000 kcal)	1414.2	1347.8	1309.7	1230.6	1074.6 <sup>b</sup>

<sup>a</sup> See Table 3.

<sup>b</sup>  $p < 0.05$  for the linear tendency of the variation of the indicator based on the quintiles of ultra-processed food consumption

Studies based on household food purchases made in Brazil<sup>13</sup> and in other countries<sup>3,17</sup> found an inferiority in the nutritional quality of all ultra-processed foods when they are jointly compared with other foods.

The stratification of the Brazilian population, based on the inclusion of ultra-processed foods in the diet, indicates that the 20.0% of Brazilians who consume fewer ultra-processed foods meet or are close to international recommendations regarding all nutritional indicators of the diet considered in this study, with the exception of sodium. On the other hand, the 20.0% of Brazilians who consume more ultra-processed foods have excessive total, saturated and trans fat content, excessive free sugar and sodium, and insufficient fiber and potassium content. This finding indicates that the reducing ultra-processed food consumption is a natural way to promote healthy eating in Brazil. The high sodium content found in the three fractions of the diet, considered in this study, indicate that the solution to the excessive sodium consumption in Brazil requires both a reduction in sodium content added by food manufacturers to processed and ultra-processed foods, and a reduction in salt quantities that are added to culinary preparations.

The average protein content in the Brazilian diet (17.2% of the calories) exceeds the recommended level for this nutrient (10.0%-15.0%)<sup>30</sup> and is due to the high protein content observed for natural or minimally processed food (19.5%), caused by the large amount of beans and meat included in the Brazilian diet. In any case, the adverse health effects that result from high protein intake are unclear and apparently only occur, as in the case of kidney function damage, when intake is more than two times the recommendation's upper limit.<sup>31</sup>

On the other hand, recent studies have indicated that increases of between 10.0% and 20.0% in protein content increase the diet's satiation factor and prevent excessive calorie consumption.<sup>4,25</sup>

Among the highlighted strengths of this study are: the strictly probabilistic character of the studied sample and the national representativeness, ensured by there being more than 30 thousand people involved, who reside in urban and rural areas from various regions of Brazil; the two 24-hour food records; and the use of a new food classification system, which groups every consumed item according to the industrial processing involved in its production.

This study's limitations are based on the inherent potential biases when using food records: underestimating food consumption, modifying habitual consumption during the days included in the study, differences between the actual and standardized recipes and differences between the nutritional composition of the consumed foods and the composition indicated by the nutritional composition table used. To minimize these biases, the collection instrument was pre-tested and validated, quality control procedures were performed during data collection and inconsistent records were deleted and replaced with imputed values.<sup>6</sup> In addition, the food composition table of foods used was specifically built for this study, including recipes that are more consistent with the culinary habits of Brazilian people. As the instrument used to record food consumption was not designed to evaluate the food according to the industrial processing to which they were submitted, some consumption items may have been misclassified. Classification errors are more likely with items such

as pizzas, sweets and fruit juices, which can be both culinary preparations from the first group and industrialized products from the third group. Whenever any absence of information was observed in the records that allowed a distinction to be made between culinary preparations and industrialized products, such as details regarding the recipe or the product's brand, the most common alternative was chosen based on cases where there was information. Finally, the study did not include people aged less than 10 years, meaning that its results only apply rigorously to the Brazilian adolescent and adult population.

The importance of verifying the negative effects from consuming ultra-processed food to the nutritional quality of the Brazilian diet has been growing in significance since the 1990s, this being the period in

which sales of ultra-processed foods began expanding strongly in Brazil and, more generally, in all middle income countries.<sup>14,26</sup> In addition, surveys regarding food purchasing for home consumption, performed in metropolitan areas in Brazil between 1987-1988 and 2008-2009, indicated systematic increases in ultra-processed food involvement and a concomitant reduction in the inclusion of natural foods or minimally processed foods and culinary ingredients such as oils and sugar.<sup>9</sup>

The results of this study support the main recommendation from the new edition of the *Guia Alimentar para a População Brasileira* (Dietary Guidelines for the Brazilian population):<sup>11</sup> "Always prefer natural or minimally processed foods and freshly made dishes and meals to ultra-processed foods".

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## ANNEX

Classification of foods based on the industrial processing they were submitted to before their acquisition.

Group	Definition and characteristics	Examples
Natural or minimally processed foods and culinary preparations with these foods as their base	Natural foods are obtained directly from plants or animals (such as leaves and fruit or eggs and milk) and are purchased ready for consumption without having undergone any alteration after leaving the natural source. Minimally processed foods are natural foods that, prior to their acquisition, underwent minor changes that do not involve adding substances to the food. Cleaning, removal of non-edible parts, fractioning, drying, packaging, fermentation, pasteurization, refrigeration, freezing, milling and refinement are examples of the processes that natural foods go through. Culinary preparations based on these foods include natural or minimally processed foods being used as the main item in the recipe with all of the remaining ingredients, including culinary ingredients such as oils, fats, sugar and salt, other natural or minimally processed foods (such as garlic and onion) and even processed or ultra-processed foods (such as cheeses and processed meats) when they are included as secondary items in the culinary preparations. These preparations are prepared in domestic kitchens, traditional restaurants or places similar to these.	Vegetables, greens, fruits, potatoes, cassava and other roots and tubers <i>in natura</i> or packaged, fractionated, chilled or frozen, white, brown or parboiled rice, in bulk or packaged, corn grain or on the cob, wheat grain and other cereals, beans of all colors, lentils, chickpeas and other legumes, fresh or dried mushrooms, dried fruits, fruit juices and pasteurized fruit juice and fruit juice with no added sugar or other substances, nuts, walnuts, peanuts and other oilseeds with no added salt or sugar, cloves, cinnamon, spices in general and fresh or dried herbs, cassava, corn or wheat flour and fresh or dried pasta or pasta made with these flours and water, beef, pork and poultry and fresh, chilled or frozen fish, pasteurized, UHT (long-life milk) or powdered milk, plain yogurt (without added sugar, sweeteners or dyes), eggs, tea, coffee and drinking water.
Processed foods	Processed foods are manufactured by the food industry, these foods have salt, sugar or any other commonly used culinary substance added to the natural or minimally processed food to make it last longer and be more pleasing to the palate. These are products that are directly derived from food and are recognized as versions of the original foods. The processing techniques used for these products resemble culinary techniques, possibly including cooking, drying, fermentation, packing in tins or glass and using preservation methods such as salting, pickling, curing and smoking.	Canned vegetables, corn or peas, fruits in syrup, candied fruits, salted meats, canned fish and fish preserved in oil, cheeses made from milk and salt and bread made from wheat flour, water, yeast and salt (but not containing other added substances such as hydrogenated fat and additives).
Ultra-processed foods	Ultra-processed foods are industrial products that are made entirely or mostly of substances that have been extracted from food (oils, fats, sugar, starch, proteins), derived from food constituents (hydrogenated fats, modified starches) or synthesized in a laboratory based on organic materials such as oil and coal (colorants, flavorings, flavor enhancers and other additives used to give the products attractive sensory properties). Manufacturing techniques include extruding, moulding and preprocessing for frying or baking.	Sliced bread, hamburger or hot dog processed bread, sweet breads and baked products whose ingredients include substances such as hydrogenated vegetable fat, sugar, starch, whey, emulsifiers or other additives, sweet and savory biscuits, chip-like snacks, processed sweets and treats in general (candies, ice creams, chocolates), soft drinks, artificial juices, sweetened and flavored dairy drinks, energy drinks, sauces, margarine, processed meats, processed ready to heat dishes, burgers, hot dogs, chicken or fish nugget, cereal bars.

Adapted from the *Guia Alimentar para a População Brasileira* (Dietary Guidelines for the Brazilian population) (Ministério da Saúde, 2014).