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Estimated polyphenol intake and major food sources of the Brazilian population: changes between 2008–2009 and 2017–2018

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Abstract

Assessing the dietary intake of polyphenols and their major food sources is the first step towards documenting the associations with health outcomes. Considering recent changes in dietary patterns of the Brazilian population, continuous monitoring of polyphenol intake is important. Thus, the present study was conducted to estimate the polyphenol intake and major food sources in the diet of the Brazilian population using data from the most recent National Dietary Survey (NDS, 2017–2018), to characterise the intake changes according to demographic characteristics and to compare the intake over the past decade in Brazil. Data from two cross-sectional population-based surveys were analyzed in the study. Trends in polyphenol intake and major food sources were estimated using food consumption data from NDS 2008–2009 (*n* 34 003) and 2017–2018 (*n* 46 164). The median (25–75th percentiles) of energy-adjusted polyphenol intake in 2017–2018 was 216·3 mg (125·3–495·2 mg) per 1000 kcal/d (4184 kJ/d), representing an increase of 12·3 mg/d from 2008–2009. However, unadjusted polyphenol intakes were similar between the surveys (medians: 364·3 mg/d in 2008–2009 and 366·9 mg/d in 2017–2018). The main food sources of total and polyphenol intake classes presented some variations between 2008–2009 and 2017–2018, with greater contribution of beans preparations, salads and tea to polyphenol intake, and decrease of orange contribution. Our study provided an updated information on polyphenol intake and its major food sources. The median intake remains lower than the reported by other populations. Furthermore, the results may contribute to future studies investigating temporal trends in polyphenol intake and disease risk.

Key words: Polyphenols: Phenolic acids: Flavonoids: Stilbenes: Lignans: Brazilian population

Polyphenols are a large group of plant secondary metabolites commonly distributed in fruits, vegetables, beans, cereals, coffee, wine and tea. Accumulating evidence indicates that polyphenols exert important biological properties, such as antioxidant, anti-inflammatory and anti-proliferative activities[1,2]. There is also a growing body of cohort studies showing inverse associations between polyphenols intake and the risk of chronic diseases, mainly CVD[3,4], type 2 diabetes[5,6], neurodegenerative diseases[7,8] and some types of cancer[9–11].

Despite evidence on the benefits of higher consumption of dietary polyphenols, the paucity of detailed information on population-level intakes compromises the establishment of dietary recommendations[12,13]. Furthermore, since the different structural characteristics of polyphenols influence their bioavailability and bioactivity (e.g. glycosylation pattern and degree of polymerisation), the assessment of total and individual polyphenols intake and their major food sources is key to documenting associations between polyphenols and health outcomes[13].

Our research group has estimated the total and individual polyphenol intake in a representative sample of Brazilian general population, using data from the National Dietary Survey (NDS) 2008–2009[14]. Considering changes in food intake patterns of Brazilian population over the years[15], it is important to determine the evolution of polyphenols intake throughout time. Therefore, the purpose of the present study was to: (1) estimate the polyphenol intake and major food sources of the Brazilian population using data from the NDS 2017–2018; (2) characterise the polyphenol intake by demographic characteristics and (3) compare the intakes of polyphenols and major food sources over the past decade in Brazil.

Abbreviation: NDS, National Dietary Survey.

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Methods

Study population

The data of the present study were retrieved from the NDS 2008–2009 and 2017–2018 editions. The NDS is a cross-sectional survey conducted along with the Household Budget Survey (HBS), a nationwide survey designed to assess Brazilian households' consumption structures. In summary, HBS adopted a two-stage sampling method involving stratified census sections, according to their geographical areas, urban or rural areas, and socio-economic classes. In the first stage, the sectors were randomly selected by systematic sampling with probability proportional to the number of households and, in the second stage, the households were selected by simple random sampling. The strata were evaluated during 12-month period to ensure representativeness throughout the year.

In the 2008–2009 NDS, individual food intake was collected in a random subsample of 24·3 % of the households sampled for the HBS edition, which corresponded to 34 003 subjects ≥10 years old (see online Supplementary Fig. 1a). In the 2017–2018 edition, 20 112 households were randomly selected for data collection on individual food intake, which represented a subsample of 34·7 % of the households sampled for the HBS edition. Thus, the final sample of the 2017–2018 NDS included 46 164 subjects ≥10 years old (see online Supplementary Fig. 1b).

Dietary intake

The instrument used to collect information about dietary intake was different in the two NDS editions. In the 2008–2009 NDS, individual food intake was collected from dietary records. The participants were guided to report all food and beverages consumed on two non-consecutive days, including measurement units, the amount, cooking method, time, place (inside or outside the home) and day of consumption (weekdays or weekends). The dietary records were revised by trained professionals, which entered the information into a digital database created for the survey. In the 2017–2018 NDS, individual food consumption was collected using 24-h dietary recalls. The researchers conducted personal interviews to assess foods and beverages consumed during the previous day of the interview (including weekends), using two 24-h dietary recalls collected in non-consecutive days. The interview was conducted using a software designed specifically for the survey, following sequential stages based on the Multiple-Pass Method[16]. Recipes mentioned in both dietary records and 24-h dietary recalls were converted into ingredients to estimate the amount of ingredients in mixed dishes.

Polyphenol content and intakes

The steps followed to match correspondence between food items in the 24-h dietary recalls and in food composition database on polyphenols were the same adopted previously[14]. The Phenol-Explorer database (www.phenol-explorer.eu/) was used to identify the polyphenol contents in foods, encompassing data on 501 different polyphenols in more than 450 foods. Polyphenol content values included in Phenol-Explorer database were obtained by different analytical methods. The majority of individual polyphenols were determined by reverse-phase HPLC, except for proanthocyanins, which considered data of normal-phase HPLC. In the case of polyphenols that cannot be released with normal extraction conditions (e.g. lignans in all foods, ellagic acid in walnuts and hydroxycinnamic acids in cereals, legumes and olives), data corresponding to HPLC after basic or acid hydrolysis were considered[17].

In the case of regional foods and beverages (e.g. açai and yerba mate tea) and other highly prevalent items in the Brazilian diet (e.g. rice, beans and orange), we used data from foods collected and analysed in Brazil by HPLC. We also used data from Brazilian Food Composition Database (TBCA, available in www.tbca.net.br/), a database developed by the University of Sao Paulo with data on flavonoid content in regional and other commonly consumed foods in Brazil, analysed by HPLC[18].

The effects of different cooking and processing methods on the polyphenol content were taken into account to allow accurate measurements of polyphenol intake, using retention factors from Phenol-Explorer database. The retention factor estimates the polyphenol content in processed foods by considering weight loss or water gain during cooking and processing[19].

The total polyphenol intake was estimated based on the ingredient content in the recipe. The polyphenol content was calculated on the basis of contents of the ingredient and their polyphenol composition for recipes including polyphenol-containing ingredients.

The daily intake of individual polyphenols was estimated based on the two dietary records (2008–2009 NDS) and the two 24-h dietary recalls (2017–2018 NDS). We used the same food composition data to analyse food intake in both NDS editions. Since food composition data is reported in mg/100 g, individual polyphenol intake from each food was calculated by multiplying contents of polyphenol by daily consumption amount of each food and dividing by 100. Total polyphenol intake was calculated by summing up intakes from all food sources consumed. The polyphenol intake was also calculated as aglycone equivalents for foods containing polyphenols in glycosides and esters forms, by removing the contribution to molecular weight of the non-phenolic part of the molecule for each polyphenol.

Demographic information

Demographic variables were obtained through face-to-face interviews in the households using a structured questionnaire. The differences of total polyphenol and classes intake were assessed according to sex, age, race, Brazilian region and household area (urban or rural). The Brazilian regions consisted of five categories: North (states of Acre, Amapá, Amazonas, Pará, Rondônia, Roraima and Tocantins), Northeast (states of Alagoas, Bahia, Ceará, Maranhão, Paraíba, Piauí, Pernambuco, Rio Grande do Norte and Sergipe), Middle-West (states of Goiás, Mato Grosso and Mato Grosso do Sul), Southeast (states of Espírito Santo, Minas Gerais, Rio de Janeiro and São Paulo) and South (states of Paraná, Rio Grande do Sul and Santa Catarina).

Statistical analysis

Polyphenol intake distribution was analysed using the Kolmogorov–Smirnov test, and it did not follow a normal

Table 1. Number of individual polyphenols consumed in 2008–2009 and 2017–2018 NDS

	2008–2009		2017–2018	
	Aglycones, glycosides and esters	Aglycones	Aglycones, glycosides and esters	Aglycones
Phenolic acids				
Hydroxybenzoic acids	11	10	20	7
Hydroxycinnamic acids	57	17	56	13
Hydroxyphenylacetic acids	4	4	4	4
Hydroxyphenylpropanoic acids	2	2	1	1
Flavonoids				
Flavan-3-ols	10	4	13	5
Flavones	14	6	11	4
Flavonols	32	3	56	6
Flavonones	8	3	12	7
Anthocyanins	26	6	41	4
Isoflavonoids	13	4	13	4
Chalcones	0	0	1	1
Dihydroflavonols	0	0	2	2
Proanthocyanidins	9	9	15	15
Lignans	13	13	11	11
Stilbenes	9	6	7	4
Other polyphenols	45	37	45	36
Total	253	124	308	124

NDS, National Dietary Survey.

distribution. Thus, dietary polyphenol intakes were presented as medians and 25th and 75th percentiles. The differences in intake between demographic groups were tested using the Kruskal–Wallis test, and P values <0·05 were considered significant. Since polyphenol intake increases according to higher food consumption, the polyphenol intake was also calculated in energy-adjusted terms (mg of polyphenols per 1000 kcal/d (4184 kJ/d) of total energy consumed). Main food contributors to polyphenol intake were determined by percentage of contribution. Comparisons of polyphenol estimates between NDS editions were presented by the differences of medians (2017–2018 medians subtracted by 2008–2009 medians). Analysis were performed using sample weights to allow population representativeness, using Stata software version 17.

Results

Polyphenol intake

Information on 34 003 participants from the 2008–2009 NDS and 46 164 subjects from the 2017–2018 were available for analysis. After converting recipes into ingredients, out of the 506 food items considered in the 2017–2018 NDS dietary recalls, 234 have polyphenol content described for analysis (168 from Phenol-Explorer database and sixty-six from TBCA and published Brazilian data). A total of 308 polyphenols were shown in these foods in aglycone, glycoside, esters and polymers forms, which correspond to an increase of 21·7 % compared with 2008–2009 (Table 1).

The energy-adjusted polyphenol intake as aglycone equivalents for the Brazilian population, according to demographic characteristics, is reported in Table 2. The daily median intake of total polyphenols for the 2017–2018 was 216·3 (25th–75th percentile 125·3–495·2) mg/1000 kcal/d, which is 12·3 mg/d greater than in the 2008–2009. However, comparing the unadjusted polyphenol intake between 2008–2009 and 2017–2018, the medians were similar (364·3 and 366·9 mg/d, respectively, see online Supplementary Table 1).

The total polyphenol, phenolic acids, flavonoids and other polyphenols energy-adjusted intake was higher among females than among males (all $P < 0·0001$) and also higher among Whites if compared with other ethnic groups (all $P < 0·0001$). The phenolic acids and other polyphenols intake increased with age; however, the highest flavonoids intake was observed among children (10–13 years). Subjects living in South and Southeast consumed more polyphenols compared with those living in other regions ($P < 0·0001$), and those living in urban areas consumed more total polyphenols, flavonoids and other polyphenols than those living in rural areas ($P \leq 0·0092$).

The differences of polyphenol subclasses intake as aglycone equivalents and the contribution to total polyphenol intake between 2008–2009 and 2017–2018 are shown in Table 3. The most consumed polyphenol subclass is still the hydroxycinnamic acids, contributing to 65 % to total polyphenol intake in the 2017–2018 edition. Flavanones intake is still the second most consumed subclass, with 15·3 % contribution to total polyphenol intake in 2017–2018, despite of decrease in consumption between 2008–2009 and 2017–2018. The contribution of flavonols to total polyphenol intake increased from 1·6 % to 7·4 % between 2008–2009 and 2017–2018. Other flavonoid subclasses intake also increased in 10 years, although to a lesser extent. Flavones and flavan-3-ols contribution to total polyphenol intake increased from 2·6 % to 3·1 % and from 2·7 % to 2·9 %, respectively, comparing 2008–2009 with 2017–2018.

Major food sources and 10-year changes

The main food sources of total polyphenol intake and classes showed some variations between 2008–2009 and 2017–2018 (Table 4). Coffee was the most significant food source for hydroxycinnamic acids and phenolic acids, contributing with 216·4 mg (59·4 %) and 198·5 mg (54·1 %) to the daily total

Table 2. Energy-adjusted total and polyphenol class intake (mg/1000 kcal/d as aglycone equivalents) by demographic characteristics in 2017–2018 NDS and changes from the 2008–2009 NDS,†

		Total polyphenols			Phenolic acids			Flavonoids			Other polyphenols‡		
	n	Median	25–75th percentiles	Δ	Median	25–75th percentiles	Δ	Median	25–75th percentiles	Δ	Median	25–75th percentiles	Δ
All	46 164	216·3	125·3–495·2	12·3	91·8	52·3–153·6	8·6	67·0	28·9–335·8	3·0	6·7	4·7–9·5	4·0
Sex													
Male	21 460	207·9	124·8–454·1	13·7	86·1	49·2–145·0	5·6	56·6	26·3–279·8	-0·6	6·3	4·6–8·9	3·6
Female	24 704	252·3	147·5–560·8	37·9	97·1	55·0–161·2	11·6	77·4	32·0–384·6	6·7	6·9	4·9–10·1	4·2
P		<0·0001			<0·0001			<0·0001			<0·0001		
Race													
White	17 204	240·8	141·7–548·4	35·8	95·1	53·8–158·4	17·7	74·9	31·2–369·8	1·0	6·9	4·9–10·2	4·2
Others	28 960	224·6	131·6–485·5	21·1	89·7	51·4–150·2	0·3	62·0	27·2–311·9	7·7	6·4	4·6–9·1	3·7
P		<0·0001			<0·0001			<0·0001			<0·0001		
Age (years)													
10–13	3271	205·8	122·2–472·1	32·5	52·3	27·1–102·8	-3·6	78·6	36·1–352·0	9·1	5·4	3·9–7·8	2·8
14–18	4407	198·1	119·6–474·3	11·5	60·7	31·7–111·4	0·8	70·5	30·6–339·6	-3·3	6·0	3·9–8·1	3·4
19–59	30 150	227·9	134·6–497·9	23·0	92·5	54·6–153·4	6·9	63·5	27·9–317·9	0·1	6·7	4·8–9·5	4·0
≥60	8336	269·0	158·0–577·5	43·7	117·3	73·0–185·3	8·9	73·2	30·4–377·9	17·7	7·6	5·4–10·8	4·9
P		<0·0001			<0·0001			<0·0001			<0·0001		
Area													
Urban	35 391	232·3	137·3–519·9	30·3	90·2	51·0–151·7	10·3	69·0	29·6–350·7	1·7	6·8	4·8–9·7	4·1
Rural	10 773	226·6	132·5–466·6	12·0	98·8	59·6–165·0	-3·0	56·2	25·2–260·5	9·9	6·1	4·4–8·6	3·6
P		0·0092			<0·0001			<0·0001			<0·0001		
Brazilian region													
North	6836	214·6	123·5–446·2	12·2	72·2	46·1–119·6	3·3	53·5	26·2–283·9	-22·2	5·8	4·2–8·1	3·4
Northeast	16 097	195·2	120·3–416·5	-3·6	82·9	49·1–134·7	-12·5	56·8	25·4–252·9	15·0	5·8	4·2–8·0	3·2
Midwest	5740	207·2	122·5–432·7	36·6	85·4	46·9–149·5	18·2	57·9	26·4–223·8	-5·6	6·2	4·4–8·9	3·5
Southeast	11 471	236·4	145·0–521·8	26·2	99·3	54·6–159·2	15·5	67·6	29·6–352·6	-4·2	7·2	5·2–10·2	4·4
South	6020	353·3	173·9–734·1	135·6	110·3	60·4–207·0	32·9	119·6	43·1–529·7	37·7	7·8	5·3–11·5	4·8
P		<0·0001			<0·0001			<0·0001			<0·0001		

NDS, National Dietary Survey.
† Comparisons across categories were performed by using the Kruskal–Wallis test.
‡ Other polyphenols as the sum of lignans, stilbenes, alkylphenols, alkylmethoxyphenols, methoxyphenols, furanocoumarins, hydroxybenzaldehydes, hydroxycoumarins, tyrosols, catechol, phenol, pyrogallol and arbutin.
Estimates were performed using sample weights to allow population representativeness.

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Table 3. Polyphenol subclasses intake (mg/d) as aglycone equivalents* in 2017–2018 NDS and their contribution (%) to polyphenol total intake in 2017–2018 and 2008–2009 NDS

Polyphenol subclasses	Median	25–75th percentiles	Top five most consumed individual polyphenols	Contribution of subclass (%) to polyphenol total intake in 2017–2018	Contribution of subclass (%) to polyphenol total intake in 2008–2009
Hydroxybenzoic acids	1·7	0·9–3·8	Gallic acid (20·1 %), 4-hydroxybenzoic acid (19·5 %), protocatechuic acid (18·2 %), vanillic acid (17·2 %) and 5-O-galloylquinic acid (15·2 %)	0·8	0·3
Hydroxycinnamic acids	144·6	84·0–247·7	5-caffeoylquinic acid (29·9 %), 4-caffeoylquinic acid (23·3 %), 3-caffeoylquinic acid (22·2 %), ferulic acid (5·0 %) and 5-feruloylquinic acid (4·3 %)	65·0	66·0
Flavan-3-ols	6·5	1·8–24·7	Epigallocatechin (36·4 %), procyanidin B1 (18·3 %), epicatechin (11·7 %), catechin (9·8 %) and procyanidin dimer B2 (6·1 %)	2·9	2·7
Flavones	6·9	4·4–9·9	Apigenin 6,8-C-galactoside-C-arabinoside (58·7 %), apigenin 6,8-C-arabinoside-C-glucoside (39 %), luteolin (1·9 %), apigenin (0·3 %) and apigenin 7-O-apiosyl-glucoside (0·1 %)	3·1	2·6
Flavonols	16·4	10·8–24·7	Quercetin (63·6 %), quercetin 3-O-rutinoside (14·7 %), kaempferol (9·2 %), kaempferol 3-O-glucoside (3·2 %) and kaempferol 3-O-rhamnosyl-rhamnosyl-glucoside (2·1 %)	7·4	1·6
Flavanones	34·1	5·6–495·0	Naringenin (43·1 %), hesperetin (42·8 %), hesperedin (10·5 %), naringenin 7-O-rutinoside (2·4 %) and didymin (0·6 %)	15·3	25·4
Anthocyanins	1·1	0·5–2·8	Pelargonidin 3-glucoside (14·8 %), malvidin 3,5-O-diglucoside (13·8 %), cyanidin 3-rutinoside (12·5 %), cyanidin 3-glucoside (11·2 %) and delphinidin 3-O-glucoside (10·8 %)	0·5	0·0
Others	11·2	6·3–27·4	Lariciresinol (20·2 %), pinoresinol (11·6 %), 5-nonadecenylresorcinol (6·9 %), 4-ethylguaiacol (5·7 %) and pyrogallol (4·8 %)	5·0	1·4

NDS, National Dietary Survey.
* Aglycone consumed as such or as the conversion of ester and glycoside forms into aglycone equivalents.

polyphenol intakes of 2008–2009 and 2017–2018. Dietary intake of flavonols, anthocyanins, total flavonoids and total polyphenols from bean and preparations increased, whilst the contribution of orange and orange juice to total flavonoid and polyphenol decreased in 2017–2018 compared with 2008–2009. Tea presented higher contribution to flavan-3-ols intake in 2017–2018 compared with 2008–2009, whilst the contribution of chocolate and chocolate powder to the subclass intake decreased over the period. Tea contribution to hydroxybenzoic acids intake has also increased, as well as the contribution of salad to flavonol intake.

Discussion

Our study shows, for the first time, the 10-year trends in total and polyphenol classes intake in the Brazilian population, according to demographic characteristics. The total polyphenol and all classes intake are greater in 2017–2018 if compared with 2008–2009, after energy-adjusting. These changes are due to differences in consumption of polyphenol-rich foods (see online Supplementary Table 2), namely an increase of beans preparations, salads and tea intake, since the mean energy intake between the two surveys did not differ significantly[20]. Nevertheless, the total and polyphenol classes daily intake among Brazilians individuals remains lower than reported by other studies. Polish adults in the WOBASZ study had a mean polyphenol intake of 989 mg/d[21], adults in the French cohort SU.VI.MAX had an intake of 820 mg/d[22], and Finnish adults in the FINDIET cohort had an intake of 863 mg/d[23] (values expressed as aglycone equivalents). The total polyphenol intake by the Brazilian population is also lower than reported among American adults in NHANES, which had mean polyphenol intake of 884·1 mg/1000 kcal/d[24]. Comparing the daily intake of total polyphenol in Brazil with estimates from other Latin American countries, our values are lower than those reported to adult women in Mexican Teachers' Cohort[25].

Although these differences between countries could be explained by different dietary patterns, we highlight a nutritional issue about the Brazilian dietary pattern. Per capita fruit and vegetable intake, which was very low in 2008–2009 (69·1 g/d for men and 92·6 g/d for women), showed a slight reduction in 2017–2018 and remains far below of the WHO recommendation of at least 400 g/d to reduce the global burden of non-communicable diseases[26]. In addition to the low total and polyphenol classes intake, this finding points to low quality of Brazilian diet and emphasises the importance of actions promoting healthy eating.

Phenolic acids, followed by flavonoids, were the most consumed polyphenol class 2008–2009 and 2017–2018. In other studies, the contribution of these two classes to the total polyphenol intake was similar[21–24]. In regard to polyphenol subclasses, hydroxycinnamic acids and flavanones were the main contributors to total polyphenols intake in the two NDS editions, which is similar to other estimates developed in Mexico[25], Spain[27] and non-Mediterranean countries[28].

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Table 4. Major food sources of polyphenols of Brazilian population in 2008–2009 and 2017–2018 NDS

		2008–2009			2017–2018		
Polyphenol classes and subclasses	Rank	Food item	%	Median intake* (mg/d)	Food item	%	Median intake* (mg/d)
Phenolic acids	1	Coffee	90·6 %	139·5	Coffee	84·4 %	124·7
	2	Potato	2·5 %	3·9	Rice and preparations	3·9 %	5·8
	3	Bean and preparations	0·7 %	1·1	Bread	1·0 %	1·5
Hydroxybenzoic acids	1	Rice and preparations	54·7 %	0·4	Tea	24·7 %	0·4
	2	Beer	8·0 %	0·1	Beer	9·7 %	0·2
	3	Wine	4·0 %	0·03	Rice and preparations	6·1 %	0·001
Hydroxycinnamic acids	1	Coffee	91·8 %	140·3	Coffee	86·2 %	124·7
	2	Potato	2·6 %	4·0	Rice and preparations	3·8 %	5·5
	3	Bean and preparations	1·0 %	1·5	Bread	1·0 %	1·5
Flavonoids	1	Orange juice	57·2 %	68·7	Bean and preparations	37·6 %	41·9
	2	Orange	15·8 %	19·0	Orange juice	13·1 %	14·6
	3	Chocolate	4·7 %	5·7	Tea	4·2 %	4·7
Flavan-3-ols	1	Chocolate	51·3 %	3·2	Tea	24·0 %	1·6
	2	Chocolate powder	14·0 %	0·9	Chocolate	8·6 %	0·6
	3	Banana	2·3 %	0·1	Chocolate powder	6·4 %	0·4
Flavones	1	Bread	31·7 %	1·9	Bread	38·1 %	2·7
	2	Orange juice	17·8 %	1·1	Pasta	23·2 %	1·6
	3	Cracker	2·0 %	0·1	Cracker	4·7 %	0·3
Flavonols	1	Kale	28·0 %	1·0	Bean and preparations	49·5 %	8·1
	2	Bean and preparations	11·3 %	0·5	Salads	7·9 %	1·3
	3	Apple	7·6 %	0·3	Apple	6·0 %	1·0
Flavanones	1	Orange juice	75·0 %	44·2	Orange juice	80·0 %	27·3
	2	Orange	21·0 %	12·4	Orange	13·8 %	4·7
	3	Lemon	0·5 %	0·3	Lemon	0·4 %	0·1
Anthocyanins	1	Açaí	71·0 %	0·05	Açaí	18·0 %	0·2
	2	Grape	17·0 %	0·01	Bean and preparations	16·4 %	0·2
	3	Wine	8·5 %	0·006	Grape juice	12·6 %	0·1
Other	1	Wheat flour products	12·6 %	1·1	Coffee	13·8 %	1·6
	2	Coffee	4·6 %	0·4	Wheat flour products	6·8 %	0·8
	3	Beer	3·5 %	0·3	Orange juice	6·4 %	0·7
Total polyphenols	1	Coffee	59·4 %	216·4	Coffee	54·1 %	198·5
	2	Orange juice	16·3 %	59·4	Bean and preparations	15·5 %	56·9
	3	Orange	4·5 %	16·4	Orange juice	4·8 %	17·6

NDS, National Dietary Survey.
* As aglycone (consumed as such or as the conversion of ester and glycoside forms into aglycone equivalents).

However, we identified changes in intake of some polyphenol classes and subclasses between 2008–2009 and 2017–2018 in the Brazilian population. The intake of other polyphenols class (sum of lignans, stilbenes, alkylphenols, alkylmethoxyphenols, methoxyphenols, furanocoumarins, hydroxybenzaldehydes, hydroxycoumarins, tyrosols, catechol, phenol, pyrogallol and arbutin) increased, possibly due to differences in per capita food intake in the period. The intake of prepared foods containing these polyphenols, such as sandwiches, pasta, salads and preparations derived from bean and rice, increased in 2017–2018 compared with 2008–2009[29]. The greater intake of flavonol may be attributable to an increase in beans and preparations and salads intake, as well as other preparations in general. In the majority of preparations (e.g. rice, beans, vegetables, meats and other), onion was considered as one of the ingredients of these recipes. Since onion is a source of quercetin and its glycosylated derivatives, we believe that this could be an additional explanation to the increase in flavonol intake. Nevertheless, besides these differences in the intake of polyphenol classes and subclasses between two NDS editions, the medians are still very low, raising questions about the biological significance of this increase.

The differences in food intake between editions also justified the differences found in the main food sources of polyphenols in the Brazilian population. The contribution of rice preparations to phenolic acids intake increased in 2017–2018 compared with 2008–2009, as well as the contribution of beans preparations to flavonoid consumption. The flavonoid intake from orange was lower in 2017–2018 compared with 2008–2009, which is consistent with a reduction in orange intake over the period[29]. Tea contribution to polyphenol intake, specially hydroxybenzoic acids and flavan-3-ols, also increased. This increase may be due to an increase in consumption of tea per capita during the past decade in Brazil[29].

Comparing the 2008–2009 and 2017–2018 editions, the total and all polyphenol classes intake increased in females after adjusting for energy intake, with medians significantly greater than males. This finding is consistent with other studies[24,30,31], being associated with higher intake of polyphenol-rich foods by females. We found that there was an increase in polyphenol classes intake with substantial differences according to ethnic groups, with medians significantly higher among White compared with other groups, which corroborate results from other studies[32,33]. Phenolic acids intake increased with age in the two NDS editions, and the flavonoid intake reduced across adolescents in 2017–2018 compared with 2008–2009. This result may be attributable to thereduction in fruit intake by adolescents, which was more pronounced than in other age groups[29].

Regarding polyphenol intake across country regions, we found that South presented an increase in all polyphenol classes intake in 2017–2018 compared with 2008–2009. This result may be due to an increase in coffee, tea and wheat flour products intake, which is highly prevalent in this region. Although Southeast showed a reduction in flavonoid intake over the period, this region, as well as South, concentrated the highest average of per capita intake for the majority of fruits and vegetables. The median intake of phenolic acids was higher in rural areas, which is consistent with a greater coffee intake, although it showed a reduction between 2008–2009 and 2017–2018. The flavonoid intake was greater in urban areas, which could be justified by the higher intake of fruits (banana, apple and grape), fruit juices, wheat flour products and chocolate compared with rural areas[29].

The major strengths of the present study refer to the use of the most recent data on Brazilian population food intake, in addition to the representativeness of the sample at national level, allowing generalisability of results. Other strengths are the inclusion of the Brazilian food composition data obtained by high-quality analytical methods, besides the Phenol-Explorer, which comprises the most comprehensive database for polyphenols. The analysis of mixed dishes according to the contribution of their ingredients and the use of the retention factors is another strength, since it provides reliable data. However, the present study has also certain limitations. First, the two NDS editions collected information on food consumption through different instruments, and some differences observed may be related to the instrument. Second, the 2008–2009 and 2017–2018 NDS present transversal design, and it is not possible to evaluate the changes in polyphenol intake for the same person. Third, although Phenol-Explorer include retention factor information, there is lack of information about polyphenol content on some foods (e.g. arugula, cassava, chicory, maize, beetroot, sweet potato, watercress and pumpkin), compounds and processing methods reported in the two NDS editions. Fourth, data on some regional fruits and vegetables consumed in Brazil are still scarce. However, it is important to point that the use of the same methodological processes in the analysis of the two surveys tend to minimise bias in the results of the study.

In conclusion, our study showed a slight increase in polyphenol intake, total and classes, after adjustment for energy intake between 2008–2009 and 2017–2018. We found that there was an increase in polyphenol intake among demographic groups, with higher medians by females, Whites, adults and elderly and those living in urban areas. The main food sources for total polyphenol and classes changed over the period, which corroborates evidence on changes in food intake between the two NDS editions. Our results support further analysis on the associations between polyphenol intake and health, considering the scarcity of data for the analysis in the context of the Brazilian population. Furthermore, these results may contribute to future studies investigating temporal trends in polyphenol intake and disease risks and may be useful for the establishment of dietary intake recommendations.

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Supplementary material

For supplementary material/s referred to in this article, please visit https://doi.org/10.1017/S0007114522003221

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