Consumption of stimulant drinks and consequent ingestion of phenolic compounds and caffeine

Consumo de bebidas estimulantes e consequente ingestão de compostos fenólicos e cafeína

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ABSTRACT

CANELA, M. D.; BASTOS, D. H. M.; PINHEIRO, M. M.; CICONELLI, R. M.; FERRAZ, M. B.; MARTINI, L. A. Consumption of stimulant drinks and consequent ingestion of phenolic compounds and caffeine. *Nutrire:* rev. Soc. Bras. Alim. Nutr. = J. Brazilian Soc. Food Nutr., São Paulo, SP, v. 34, n. 1, p. 143-157, abr. 2009.

Coffee and yerba maté beverages are widely consumed by the South American population. In adition to the stimulant characteristic, due the presence os caffeine in its composition, these beverages contribute to the intake of bioactive compounds such as phenolic compounds. The content of these compounds justify the several health benefits atributed to yerba maté and coffee: antioxidant, antimutagenic, chemioprevention, antiatherogenic and hepatoprotective effects. The aim of this study was to verify the consumption of these beverages and consequent intake of bioactive compounds (caffeine and total phenolics) by the Brazilian population. A sub analysis of the BRAZOS study (a cross-sectional study) provided data about the beverages intake. The content of bioactive compounds was compiled from original articles and reviews indexed at ISI Web of Knowledge. Coffee (consumed by aproximately 75% of population) and yerba maté (most consumed in the South region) are an important source of bioactive compounds in the Brazilian diet, being chimarrão the major contributor for the intake of these compounds due the large volume ingested.

Keywords: Yerba maté. *Ilex paraguariensis*.
Coffee. Phenolic compounds.
Intake. Stimulant beverages.
Antioxidant. Bioactive compounds.

RESUMEN

Las bebidas café y yerba maté son extensamente consumidas por la población de América del Sur. Además de su característica estimulante, debido a la presencia de cafeína en su composición, estas bebidas contribuyen para el consumo de compuestos bioactivos tales como los compuestos fenólicos. El contenido de fenólicos justifica los muchos beneficios para la salud humana atribuidos a estas infusiones: antioxidantes, anti-mutagénicos, quimiopreventivos, antiaterogénicos y hepatoprotectores. El objetivo de este estudio fue evaluar el consumo de estas bebidas y la consiguiente ingestión de compuestos bioactivos (cafeína y fenólicos totales) por la población brasileña. Datos sobre el consumo de estas infusiones fueron retirados de un sub-análisis del estudio BRAZOS (un estudio transversal). Los valores de la concentración de compuestos bioactivos en las infusiones fueron compilados de los artículos originales y revisiones indexadas en la base de datos ISI Web of Knowledge. El café (consumido por aproximadamente 75% de la población) y la yerba mate (consumido más en la región sur) son fuente importante de compuestos bioactivos en la dieta brasileña, siendo el chimarrão *el mayor contribuyente para el consumo de estos compuestos debido al gran volumen ingerido.*

Palabras clave: Yerba mate.
***Ilex paraguariensis*. Café. Fenólicos.**
Consumo. Bebidas estimulante.
Antioxidante. Compuestos bioactivos.

RESUMO

Infusões de café e erva-mate são largamente consumidos pela população sul-americana. Além da propriedade estimulante, devido à presença de cafeína na composição destes, estas bebidas contribuem para a ingestão de compostos bioativos como os compostos fenólicos. A presença destes compostos biativos estão relacionados a muitos dos efeitos benéficos à saúde humana atribuídos a estes infusos: ação antioxidante, antimutagênica, quimiopreventiva, antiaterogênica e hepatoprotetora. O objetivo deste estudo foi avaliar a ingestão destas bebidas e consequente ingestão de compostos bioativos (cafeína e fenólicos totais) pela população brasileira. Dados sobre o consumo das infusões foram retirados de uma subanálise da estudo BRAZOS (um estudo transversal). Os valores do conteúdo de compostos bioativos nas infusões foram compilados de artigos originais e revisões indexados na base de dados ISI (Web of Knowledge). Café (consumido por aproximadamente 75% da população) e erva-mate (consumida principalmente na região Sul) são importantes fontes de compostos bioativos na dieta brasileira, sendo o chimarrão a infusão responsável pela maior ingestão destes compostos devido ao alto volume ingerido.

Palavras-chave: Erva-mate.
***Ilex paraguariensis*. Café. Fenólicos.**
Ingestão. Bebidas estimulantes.
Antioxidante. Compostos bioativos.

INTRODUCTION

The availability of accurate and complete data on food composition is crucial to estimate the dietary intake of bioactive substances that might help reducing the incidence of non-transmissible diseases. This kind of information is the core of epidemiological studies aiming to establish the relationship between dietary habits and risk of cardiovascular diseases, cancer and other pathological conditions.

Whilst coffee has been reported to increase cardiovascular risk factors including blood pressure and plasma homocysteine (OLTHOF et al., 2001) other investigations have demonstrated its protective effects on diseases as type 2 diabetes, Parkinson's disease and liver disease (DÓREA; COSTA, 2005). Several reviews and epidemiological studies dealing with the relationship between coffee consumption and health issues were published recently (BIDEL; HU; TUOMILEHTO, 2008; CADDEN; PARTOVI; YOSHIDA, 2007; HIGDON; FREI, 2006; KLATSKY et al., 2008; MANDEL, 2002; TAYLOR, 2008; SONG et al., 2008).

Coffee is one of the most important beverages worldwide. It is consumed by 50% of Americans everyday and is the second most valuable commodity in the world. There are several kinds of coffee preparations, such as percolation, filtration, boiling, instant, espresso. Coffee preparation influences in a direct way the amounts of bioactive compounds present in the beverage (WOLF; BRAY; POPKIN, 2008). Among the beverages, black tea, as well as coffee, are considered the major contributors to total polyphenol intake in the western diet (CLIFFORD, 2000, 2004; OVASKAINEN et al., 2008) and the main source of caffeine for many adult population (age >20 years) (DÓREA; COSTA, 2005; MANDEL, 2002).

In South America, the beverages made from yerba maté *(Ilex paraguariensis)*, besides coffee, might respond for an important amount of the ingestion of such compounds. There are no data about coffee or yerba maté consumption by the population of this region, and most of the reviews that report data about polyphenols and caffeine intake do not consider this product as a source of such compounds (CLIFFORD, 2000; WOLF; BRAY; POPKIN, 2008).

Yerba maté, which is a native tree from South America, is the raw material for three different types of beverages: *chimarrão*, widely consumed in the South of Brazil, Uruguay, Argentina and Paraguay; *tererê*, consumed in the central west of Brazil and Paraguay and maté tea, consumed in the south-east of Brazil, Argentina and Uruguay. Both chimarrão and tererê are prepared with dried green maté leaves. Chimarrão is prepared with hot water and tererê is prepared with cold water. Maté tea is prepared with roasted leaves and brewed as any other herbal tea. Maté beverages contain caffeine and phenolic acids among other bioactive substances (BASTOS et al., 2005; BASTOS et al., 2006a; BASTOS et al., 2007a; BASTOS et al., 2007b).

In the 1970s, epidemiological research focused in verifying the relationship between chimarrão consumption and esophagus cancer incidence. They concluded that the high

temperature of chimarrão ingestion among other factors (smoke and spirits drinking habits, low fruit and vegetables consumption, high ingestion of red meat) were responsible for the occurrence of neoplasia, and not the yerba maté itself (CASTELLSAGUÉ et al., 2000; DE STEFANI, 1991; DIETZ et al., 1998).

More recently, benefits of yerba maté ingestion have been published in specialized journals. Antioxidant, antimutagenic, chemoprevention, antiatherogenic and hepatoprotective effects have been described, among others. Two important revisions were published on this subject (BASTOS, 2007b; HECK; DE MEJIA, 2007).

Phenolic compounds and caffeine are secondary metabolites of plants. Food items containing polyphenols are known to help against oxidative stress, as these substances present high antioxidant activity and may act through different mechanisms (hydrogen and electron donation, metal chelating, modulation of the expression of antioxidants enzymes). Caffeine presents behavioral stimulant effects that include mental stimulation, systemic catecholamine release and sympathetic neural stimulation, leading to an increase in blood pressure and lipolysis with an increase in plasma free fatty acid concentrations (MANDEL, 2002). There is a legitimate concern about the potential adverse effects of an excessive use of caffeine in foods as many food products consumed on a daily basis contain caffeine, besides some medications (DÓREA; COSTA, 2005).

Phenolic and caffeine contents in coffee and yerba maté beverages may vary considerably due to many factors: variety, geographical and climate conditions, harvesting procedures, quality and quantity of the beans/leaves, the degree of roasting, the fineness of grinding and the amount and temperature of water used for extraction as well as the time length of extraction (BASTOS et al., 2005; BASTOS, 2006a; BASTOS, 2006b; CAMARGO; TOLEDO, 1998; ESMELINDRO et al., 2002; HÉRNANDEZ et al., 2007; KILMARTIN; HSU, 2003).

The aim of this work was to present the average daily intake of yerba maté and coffee beverages in Brazil and in its geographical regions as well as to infer about caffeine and polyphenols ingestion by the Brazilian population using published data on the content of these bioactive compounds within these beverages. Up to date, there are no data referring these information.

METHODS

In a cross-sectional population-based study, a total of 2420 individuals over 40 years old were evaluated from March to April 2006. Participants were men and women from all socio-economic classes and education levels living all over the Brazilian territory (five geographic regions, 150 municipalities). Individuals were invited to participate in a quantitative survey to characterize clinical risk factors for the fragility of fractures. The survey consisted of home-applied personal interviews conducted by trained investigators.

Sample size was calculated by probabilistic analysis to represent the Brazilian urban and rural population. Calculations and study design were based on data from the last National

Census (INSTITUTO BRASILEIRO DE GEOGRAFIA E ESTATÍSTICA, 2000) and the National Survey of Residence Sampling (PESQUISA NACIONAL POR AMOSTRAS DE DOMICÍLIOS, 2003). Residences were randomly selected and interviews were performed in week days and weekends, day or night, from March to April 2006, in order to maximize the chance of finding the target-individuals at home. The data were later weighed to reconstruct the distribution and the proportionality originally observed for the total Brazilian population. Sampling error was ± 2.2% with 95% confidence intervals.

The socioeconomic status classification used in the present study reflects the individual and household purchasing power and takes into account a list of assets as well as the educational level of the head of house. As described, individuals were classified as A, B, C, D or E depending on their score. A status has the highest purchasing power and E the lowest one. For the purposes of this study, A is considered upper class, B middle class and C, D and E lower class.

The presence of cognition deficiencies (neurological diseases or senile dementia) that could impair the participant to give consistent and trustworthy answers and the presence of more than two individuals over 40 years old in the residence was considered as an exclusion criterion in the study. The study protocol was revised and approved by the UNIFESP/EPM Ethics and Research Committee.

Beverage Intake

Beverage intake was assessed by using 24-hour recalls (24R). Upon personal interviews, participants reported in details all the beverage consumed the day before, starting from the first beverage ingested after wakening until the last meal before going to bed and including beverage taken inside and outside the residence. The 24R was applied at home and filled by an interviewer trained in the method by an experienced nutritionist. Consistence assessment and corrections were made in the applied questionnaires in order to ensure the accuracy of the notes.

Measurements of beverage were standardized according to a table of home measures, and analysis of total amount consumed by individuals were performed through Excel software, version 2007.

Statistical Analyses

Results are presented as mean, minimum – maximum observed values, and standard desviation. For comparison of the differences in beverage intakes between country regions one way analysis of variance - ANOVA was used. Significance was set as $p<0.05$.

Phenolic and caffeine content estimation

Values of caffeine and polyphenols contents in coffee and yerba maté beverages were compiled from original articles and reviews published in journals indexed in the ISI

Web of Knowledge database using the terms "find strategy" " Phenol$" AND "Yerba Maté" OR "Ilex paraguariensis" The data were normalized to be expressed as mg/mL and shown as a mean value (Table 1).

Table 1 – Bioactive compounds contents in each beverage (mg/mL)

Beverage	Caffeine	Polyphenols	Reference
Chimarrão	0.24	1.33	Bastos et al, 2006a,b/ Bastos et al,2005/ Mazzafera, 1997
Maté tea	0.07	0.71	Bastos et al, 2006a/ Bastos et al 2005
Brewed coffee	0.55	0.89	Burg,1875/ Camargo and Toledo, 1998/ Scalbert and Williamson, 2000
Instant coffee	0.57	1.24	Brug, 1875/ Camargo and Toledo, 1998/ Gunduc and El, 2003

Data expressed as the mean value found in references converted to mg/mL.

RESULTS

A total of 2286 people (1576 women and 710 men) were evaluated. The average age was 58 (40 – 102) years old.

Average values of coffee and yerba maté beverages intake, according to each country region, are in table 2 and the box plot distribuition is shown in figure 1.

Table 2 – Mean beverage intake (mL) by region

Region	Maté tea	Chimarrão	Tererê	Brewed coffee	Instant coffee
South	190.8 80 – 480	1287.2‡ 100 – 3750	0	157.7¦ 25 – 665	114.5 38.46 – 307.64
Southeast	206.9* 80 – 715	750‡	0	132.4¦ 25 – 2000	114.6 27.69 – 307.69
Center West	244.2 140 – 480	993.7‡ 495 - 1500	495	117 25 – 640	122.9 36.92 – 276.92
North	207.5 165 – 250	1000‡	0	143.8¦ 40 – 600	61.5 23.07 – 129.23
Northeast	105* 160 – 230	0	0	136.5¦ 25 – 640	96.3 18.46 – 101.54
Brazil	190.9 80 – 715	1007.7& 100 – 3750	495&	137.5 25 – 2000	102 18.46 – 307.69

& The mean values refer exclusively to regions where a consumption was mentioned
– Minimum and maximum values in mL
One Way ANOVA Test:
* $p < 0.05$ Southeast versus Northeast
‡ $p < 0.05$ Among regions
¦ $p < 0.05$ Among regions

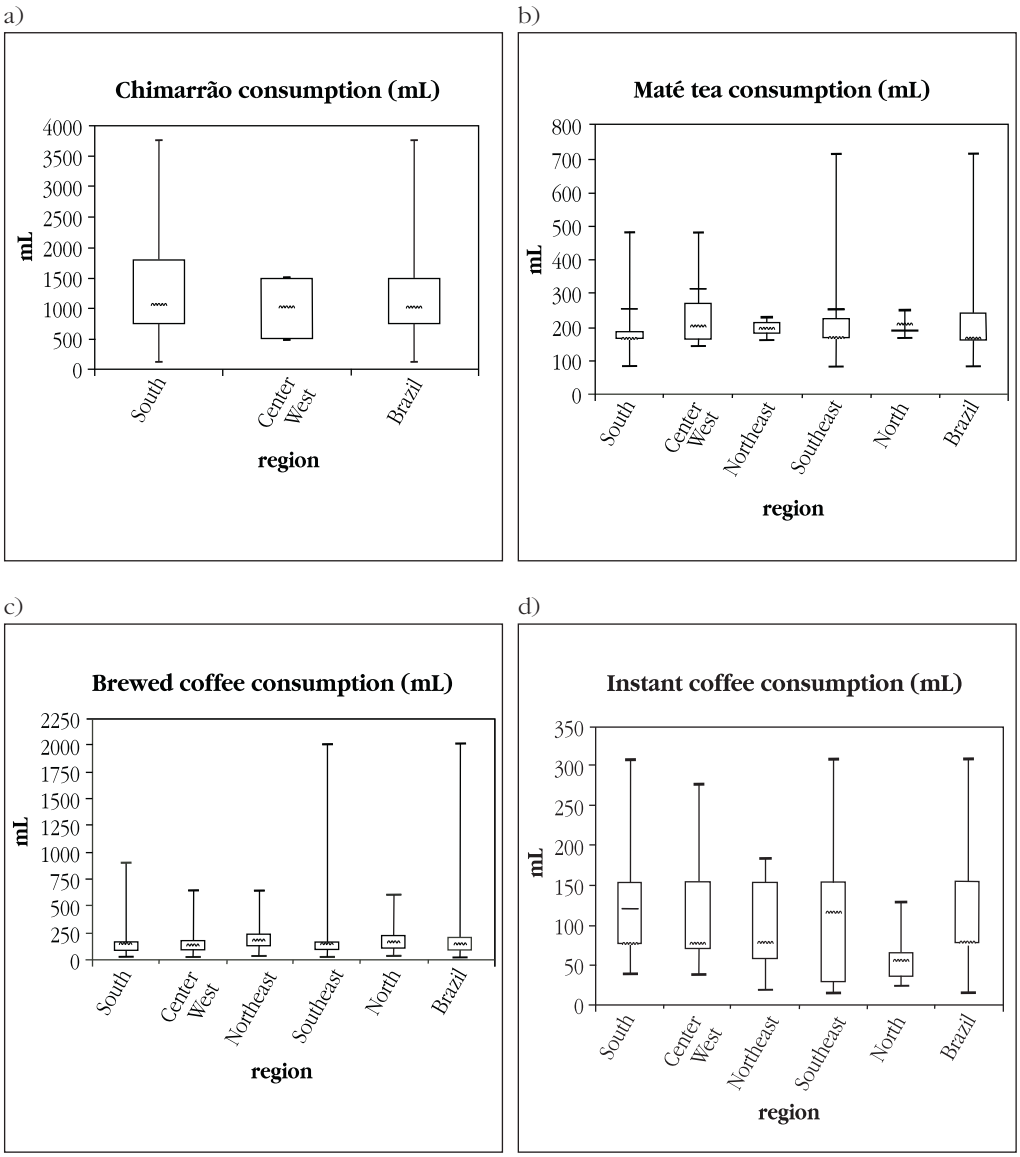


Figure 1 – Box plot distribuition of volume ingested of each beverage by region. a) Chimarrão b) Maté tea c) Brewed coffee d) Instant coffee

The highest consumption (in volume) is related to yerba maté beverages, in particular to *chimarrão*. People who traditionally consume *chimarrão* may drink from 1 to 6L a day (BARROS et al., 2000). The average consumption of chimarrão detected in this research is 1007.7mL, when excluding the data from the Northeast region, where this beverage was not mentioned even once. As expected, the highest consumption was observed in the South region, where both extremes - higher (3750mL) and lower (100mL) consumption - occurred.

Only one person mentioned the consumption of *tererê* (in the Center West region). The declared volume of ingestion is lower if compared to the consumption of *chimarrão*, despite the drinking habit, similar for both beverages that are usually prepared by compacting a certain amount of yerba maté, previously moistened with water, against the wall of a vessel made from a gourd or *"cuia"*. The beverage is drunk by sucking through a silver pipe called *"bomba"*, which has a flattened perforated disc at the end immersed in the infusion to act as a filter (MAZZAFERA,1997).

Consumption of maté tea varied from 80-715mL. The average value was 191mL/ day. There was no significant differences (5% level) among all regions.

In order to calculate the amount of bioactive compounds (phenolic and caffeine) ingested by the Brazilian population from coffee and yerba maté beverages, the mean contents of these substances were determined from different articles and the results (expressed in mg/mL) are in table 1. Since *chimarrão* and *tererê* are prepared by the consecutive addition of water to the plant material, the description of yerba maté beverage preparation was observed for the data collection.

Coffee, whether brewed or instant, shows a higher concentration of caffeine when compared to any of the yerba maté beverages. Total polyphenols content of brewed coffee is similar to the one of *chimarrão* (the beverage of yerba maté with the highest content of bioactive compounds), especially when instant coffee is considered. There are no data in the literature about bioactive contents of tereré, and this data is lacking in Tables 1 and 3. Maté tea showed the lowest content for all the analyzed bioactive substances. The amount of leaves (g)/ water (mL) ratio to prepare chimarrão is 500g/500mL, while to prepare maté tea it is 2,5 g/500mL.

Table 3 compiles the average intake of caffeine and phenolic compounds from coffee and yerba maté beverages. Daily caffeine consumption from chimarrão ranged from 181 to 311 mg while the daily caffeine consumption from brewed or instant coffee ranged from 64- 87 and 35- 70mg, respectively. Maté tea contributes to the lowest intake of caffeine, from 7-17mg. Polyphenols intake from chimarrão ranged from 997 – 1711mg, with a mean of 1072 mg – excluding the Northeast region. The consumption of polyphenols from coffee, brewed or instant, varied from 104- 178mg and 76-152mg respectively.

Figure 2 shows the consumption frequency of the different beverages by gender and geographical region. Brewed coffee is consumed by approximately 75% of the population on a daily basis, and consumers are distributed in all geographical regions. There is no difference due to gender considering coffe consumption.

Less than 3% of the population above 40 years old consumes maté tea and the distribution varies depending on the region and the gender. Chimarrão consumption is higher in the South region (9% of the population, irrespective of the gender) and decreases greatly in the other regions (no more than 1% of the population over 40 years old consume this beverage).

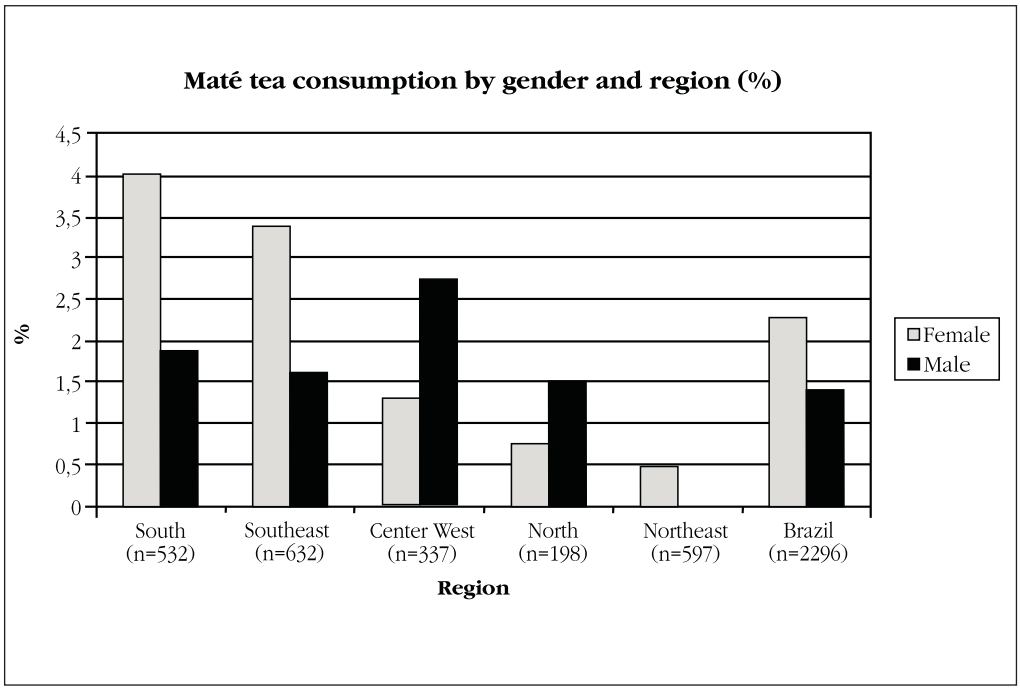
Table 3 – Mean daily intake of bioactive compounds by region and beverage (mg/day)*

Region	Beverage	Caffeine	Polyphenols
South	**Chimarrão**	311.5 ± 209	1712.0 ±1148.4
	Maté tea	13.6 ± 7.2	135.5 ± 71.6
	Brewed coffee	86.8 ± 61.9	140.4± 0.9
	Instant coffee	64.7 ± 34,3	140.8 ± 74,7
Southeast	**Chimarrão**	181.5*	997.5*
	Maté tea	14.7 ± 9.6	146.9 ± 95.9
	Brewed coffee	72.8 ± 73.2	117.8± 118.5
	Instant coffee	65.3± 51.5	142.1± 112.1
Center West	**Chimarrão**	240.5 ± 139.4	1321.7 ± 766
	Maté tea	17.3 ± 9	173.4± 90.4
	Brewed coffee	64.3 ± 54.1	104.1± 87.6
	Instant coffee	70± 54.4	152.4± 118.3
North	**Chimarrão**	242*	1330*
	Maté tea	14.7± 4.3	147.3 ± 42.7
	Brewed coffee	79.1 ± 59.4	178.4 ± 96.1
	Instant coffee	35.1 ± 23.6	76.3 ± 51.3
Northeast	**Chimarrão**	0	0
	Maté tea	7.5 ± 3.5	74.6 ± 35.1
	Brewed coffee	75.1 ± 57.5	121.5 ± 93.1
	Instant coffee	54.9 ± 27.5	119.5 ± 59.7
Brazil	**Chimarrão**	195.1 ± 202.4	1072.2 ± 1112.5
	Maté tea	13.6 ± 8.2	135.5 ± 82.1
	Brewed coffee	75.6 ± 63.3	122.4 ±102.5 102.5
	Instant coffee	58.1 ± 36.1	126.4 ± 78.6 78.6

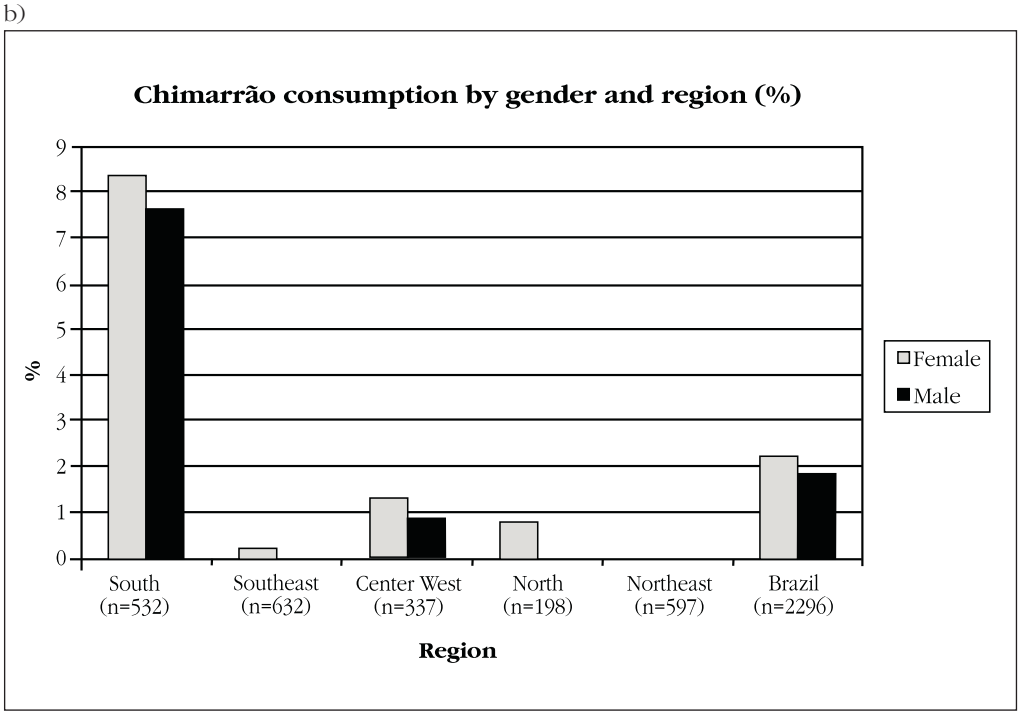
± standard deviation;

* data on single observation (n=1).

a)

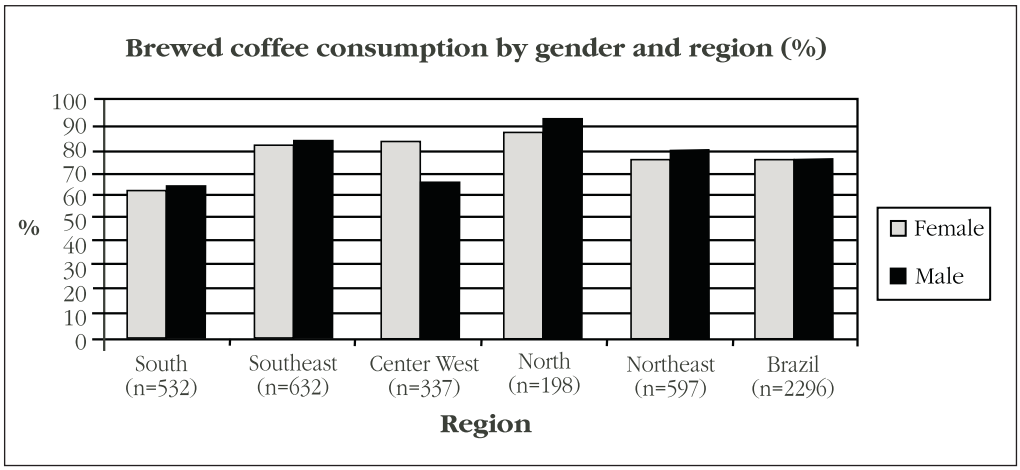

Maté tea consumption by gender and region (%)
4,5
4
3,5
3
2,5
2
1,5
1
0,5
0
%
Female
Male
South (n=532)
Southeast (n=632)
Center West (n=337)
North (n=198)
Northeast (n=597)
Brazil (n=2296)
Region

b)

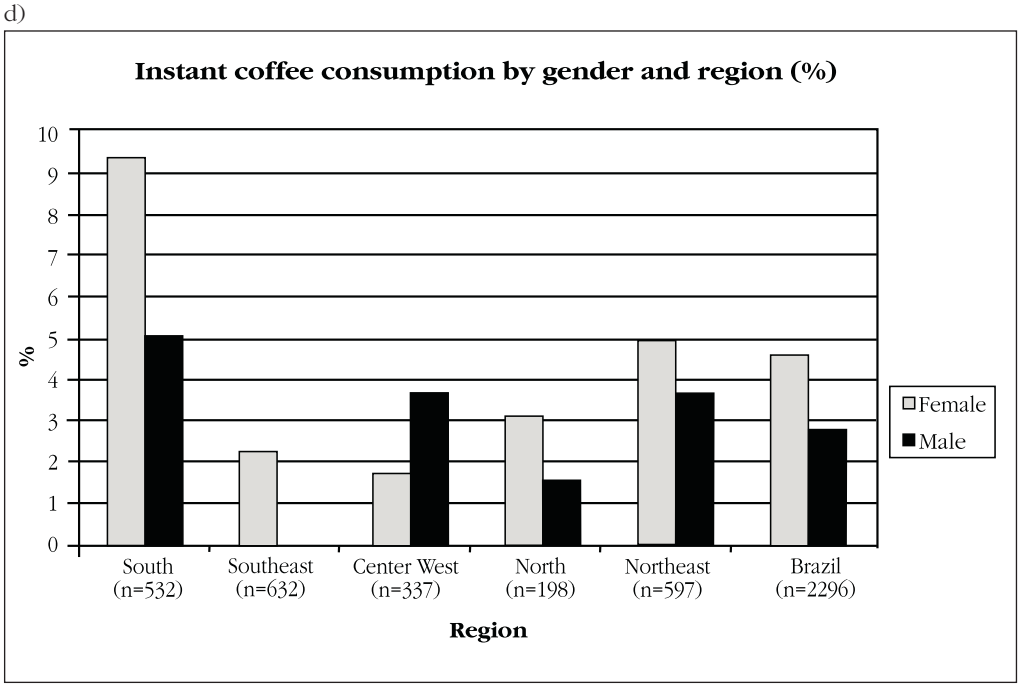

Chimarrão consumption by gender and region (%)
9
8
7
6
5
4
3
2
1
0
%
Female
Male
South (n=532)
Southeast (n=632)
Center West (n=337)
North (n=198)
Northeast (n=597)
Brazil (n=2296)
Region

(continue)

c)



d)



* "n" refers to the total of individuals evaluated in each region. *(conclusion)*

Figure 2 – Consumption of a) Chimarrão, b) Maté Tea, c) Brewed coffee and d) Instant coffee, by gender and region as % *

DISCUSSION

Data about the average daily intake of caffeine and total polyphenols from coffee and yerba maté beverages were obtained by a sub analysis of the study BRAZOS (The Brazilian Osteoporosis Study) project. A total of 2286 / 24hrs inquiries (1576 females and 710 males) in all Brazilians regions were considered. This study focused on the determinant

facts for de development of osteoporosis. The volunteers were up to 40 years old and it must be highlighted that the inquiries did not focus on compiling data about tea or coffee consumption. Nevertheless, it was possible to trace a picture about the consumption of these beverages from the collected data. It is worth pointing out that these are the first data regarding the ingestion of coffee and Yerba Maté beverages as well as the average amount of polyphenols and caffeine in the diet in the Brazilian territory.

Due to the large volumes of *chimarrão* ingested on a daily basis, this beverage represents the main source of caffeine and polyphenols in the South, Southeast, Center-west and even in the North region of Brazil. The South population is the main consumer of yerba maté, mainly due to the habit of drinking chimarrão that begins in the childhood and is transmitted from parents, to sun, cold climate and the natural occurrence of the herb in the zone.

A negative correlation between chimarrão and coffee was demonstrated in the South region ($r=-0.19$, $p<0.000$), indicating that this beverage (already consumed by the indigenous people at that region) was not replaced by coffee.

A tendency for a high average consumption of maté tea (although not statistically significant at 5% level) was observed in the Center-west region. These data follow the selling profile of this product from 10/2003-01/2008 (personal information from Leão Jr, Paraná, Brazil).

Yerba maté beverages should be considered an important source of polyphenols in the Brazilian diet. Their consumption is very different, depending on the region and on the kind of beverage, but the large volumes of *chimarrão* and *tererê* usually consumed and the tendency observed for the consumption of maté tea indicates the importance of this product as a coadjutant in the prevention of diseases.

In the South region, the daily ingestion of caffeine from *chimarrão* is 312mg. This amount is still far from the value considered of risk for homocysteine levels and cardiovascular diseases. The amount of caffeine from coffee, brewed or instant, is far below the amount consumed by people in the USA (MANDEL, 2002) and may be considered safe. For adults consuming moderate amounts of coffee (3-4 cups/d providing 300-400mg/d of caffeine), there is little evidence of health risks and some evidence of health benefits (HIGDON, 2006).

The role of polyphenls in protecting the organism against many pathological processes is unequivocal. Besides the classical antioxidant activity, these compounds seem to modulate several biological mechanisms at different cellular levels (CLIFFORD, 2004; aquela da Rice Evans).

To date, limited data on quantitative intake of polyphenols are available worldwide. In a recent work, Ovaskainen et al. (2008) identified that the Finnish adult population consumes an average of 863 ± 415mg/day of polyphenols. Phenolic acids are the predominat group, followed by proanthocyanidins, anthocyanidins and other flavonoids. Coffee and cereal were the main sources of total poyphenol intake. Clifford (2000) identified that the

UK adult population may consume from 100mg to 2g of polyphenols per day and coffee and black tea are the major dietary sources of such compounds.

The mean ingestion of polyphenols from coffee and yerba maté beverages by the Brazilian population was 1457mg/day (Table 3), what is higher than the value reported by Ovaskainen et al. (2008), however the consumption of other polypehnols from vegetables and fruits was not accounted in this study. Interestingly, the mean polyphenol intake in the South, Southeast, Center West and North regions varied from 1404 to 2128mg/day, while the value of 315.5 mg/day was observed in the Northeast region, resulting mostly from coffee consumption (Table 3). This indicates that the habit of yerba maté consumption impacts in polyphenol intake in Brazil.

CONCLUSIONS

Yerba maté and coffee beverages are important sources of bioactive compounds in the Brazilian diet. However, many publications do not recognize yerba maté as a source of bioactive compounds.

The consumption of coffee (brewed or instant) is higher than the the consumption of yerba maté beverages. However, the mayor contributor for the ingestion of bioactive compounds is chimarrão because of the higher volume ingested on a daily basis.

Yerba maté is an easy-access and low-cost product in South America. Its consumption should be encouraged in other regions than the South.

Other studies about the composition and consumption of bioactive compounds from typical beverages, for instance yerba maté, should be encouraged due the lack of data about this subject.

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Recebido para publicação em 05/08/08.
Aprovado em 06/02/09.