

# Evaluation of the pH and titratable acidity of teas commercially available in Brazilian market

Avaliação do pH e titrabilidade ácida de chás comercialmente disponíveis no mercado brasileiro

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## ABSTRACT

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### Objective

Tea has been considered a healthy alternative to other industrialized beverages. The objective of this study was to assess the erosive potential of teas commercially available in Brazil by pH and titratable acidity measures.

### Methods

Eighteen teas available in Brazilian market were selected for this study (ready to drink and brewed tea), and a brand of yerba mate (*Ilex paraguariensis*). Each product was analyzed for pH and titratable acidity. For comparison between different kinds of teas, the Student t test was used.

### Results

The mean pH values for ready to drink teas ranged between 2.89 and 4.03, while for the brewed teas and yerba mate the values ranged between 6.75 and 7.89. The difference between the two groups was significant ( $p < 0.05$ ). Regarding titratable acidity, the ready to drink teas showed mean values ranging between 3.77 ml and 12.68 ml. Brewed teas (including yerba mate) were not tested for titratable acidity because their pH values were greater than 7.0.

### Conclusion

Among the teas commercially available, ready to drink teas have lower pH values and higher titratable acidity compared to other teas. It suggests that they have an erosive potential.

**Indexing terms:** Oral health. Tea. Tooth erosion.

## RESUMO

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### Objetivo

Avaliar o potencial erosivo de chás comercialmente disponíveis no mercado brasileiro através da avaliação dos valores de pH e de titrabilidade ácida.

### Métodos

Foram selecionados dezoito chás disponíveis no mercado brasileiro (prontos para beber e para preparo em infusão), além de uma marca de erva-mate (*Ilex paraguariensis*). Cada produto foi avaliado quanto ao seu pH e titrabilidade ácida. A comparação entre os tipos de chá foi realizado pelo teste t de Student.

### Resultados

Os valores médios de pH dos chás prontos para beber variaram entre 2,88 e 4,03 enquanto que para os chás para preparo em infusão e erva mate os valores variaram entre 6,75 e 7,89. A diferença entre os dois grupos foi significativa ( $p < 0,05$ ). Em relação à titrabilidade ácida os chás prontos para beber apresentaram valores médios variando entre 3,77 ml e 12,68 ml. Os chás para preparo em infusão (incluindo a erva mate) não foram avaliados quanto a titrabilidade ácida por terem apresentado valores de pH  $> 7,0$ .

### Conclusão

Dentre os chás comercialmente disponíveis, os chás prontos para beber apresentam os menores valores de pH e os maiores valores para titrabilidade ácida comparados aos demais chás. Estes achados sugerem um potencial erosivo para este tipo de chá.

**Termos de indexação:** Saúde bucal. Chá. Erosão dentária.

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## INTRODUCTION

In recent years, significant changes happened in the eating behavior of the Brazilian population, mainly in relation to replacement of homemade and natural food by industrialized food<sup>1-2</sup>. Along with that has been also a wide diversity on the beverages consumption behavior as well on the offer of ready to drink beverages in the Brazilian market<sup>3-4</sup>.

Following this change in the eating behavior, an increase on prevalence of tooth erosion cases among children and teenagers<sup>5</sup> has been observed. The tooth erosion is characterized by a chemical wear of dental mineralized tissues without bacterial involvement<sup>6-7</sup>. Previous studies have shown a significant relationship between dental erosion and dietary behavior<sup>8-9</sup>. The majority have associated this problem with beverages present in the modern diet, for example wine<sup>10-11</sup>, sport beverages<sup>12-13</sup>, soft drinks<sup>14-16</sup> and juices<sup>13-14,17</sup>.

Teas are among the industrialized beverages commercially available on the Brazilian market. Tea consumption is associated with great benefits to health as it has been shown to have antioxidant properties<sup>18-19</sup>. Many people consume tea as replacement to other industrialized beverages that are considered harmful, due to the belief that tea is a healthier option. However, the literature is scarce in relation to studies that evaluate the erosive potential of teas commercially available in the Brazilian market through assessment of pH values and titratable acidity.

## METHODS

Eighteen commercial brands of teas available in the city of Porto Alegre, RS, Brazil were analyzed in the present study. Of these, 12 were in the ready to drink form and 6 in the teabag form. Furthermore, a commercial brand of yerba mate (*Ilex paraguariensis*) that is widely used as *chimarrão* by the local population was also evaluated. Three units of each tea or yerba mate were bought in different stores in the metropolitan region of Porto Alegre, RS. Charts 1 and 2 show the composition of tested teas.

### Tea and yerba mate samples preparation

Samples of ready to drink tea (canned or bottled) were collected directly from the product package immediately after its opening. Brewed teas were prepared using a standard method by which the tea bag was allowed to infuse in 200 ml of distilled water at 100°C for 4 minutes. The yerba mate was prepared by putting it inside a *cuia* (cup for the preparation and consumption of *chimarrão*) with a volume of 2/3 of the cup. The rest (1/3 of the *cuia*) was filled with distilled water at 100°C. After the water was added, the prepared yerba mate brew was removed from the *cuia* and filtered using a filter paper.

### Evaluation of beverages' pH values

The measurement of the beverages' pH values were made at 25°C through a pH electrode connected to an ion analyzer (DM-23, Digimed, São Paulo, SP, Brazil). Previously to the measurements the equipment was calibrated with standard solutions of pH 4.01 and 6.86. The readings were performed in triplicate for each sample.

### Titrateable acidity of beverages

In the sequence of pH measurements, the samples which showed a pH value below 7.0 were submitted to titrateable acidity analysis. Increments of 0.5 ml of 0.1M NaOH solution were added, in a tea volume of 25 ml, until pH 7 was reached. The volume of 0.1M NaOH solution (in milliliters) necessary to achieve a neutral solution was recorded and it corresponded to titrateable acidity of each beverage<sup>20</sup>. The procedure was also conducted in triplicate for each sample.

### Statistic analysis

Mean and standard deviations of all samples were calculated with Excel software (Microsoft, Redmond, WA, USA). The pH values of ready to drink teas were compared with brewed tea and yerba mate through Student t test, with significance level of 0.05, using the Statistical Package for Social Sciences version 17.0 for Windows (SPSS Inc., Chicago, Ill., USA).

**Chart 1.** Composition of the ready to drink teas tested in this study, Porto Alegre (RS), 2011.

Tea's commercial brand (manufacturer)	Composition
Black Tea zero lemon flavor (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	Water, sugar, black tea extract, acidulant citric and phosphoric acid, synthetic aroma identical to natural, preservatives sodium benzoate and potassium sorbate, artificial sweetener sodium cyclamate (45 mgs) and sodium saccharin (6,5 mgs) per 100 ml, sequestrant sodium hexametaphosphate and dimethylpolysiloxane antifoam
Black tea peach flavor (Nestea, Nestlé, São Paulo, Brazil)	Water, sugar, black tea extract, acidulant citric and phosphoric acid, sequestrant sodium hexametaphosphate, preservatives sodium benzoate and potassium sorbate, flavoring, caramel color and dimethylpolysiloxane antifoam
Black tea peach flavor (Lipton®, Ambev, Jaguariúna, Brazil)	Water, sugar, acidulant citric acid INS 330, black tea extract, concentrated peach juice, flavoring (aroma identical to natural peach), antioxidant ascorbic acid INS 300
Black tea zero peach flavor (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	Water, sugar, black tea extract, acidulant citric and phosphoric acid, synthetic aroma identical to natural, preservatives sodium benzoate and potassium sorbate, artificial sweetener sodium cyclamate (45 mgs) and sodium saccharin (6,5 mgs) per 100 ml, sequestrant sodium hexametaphosphate and dimethylpolysiloxane antifoam
Black tea lighth lemon flavor (Lipton®, Ambev, Jaguariúna, Brazil)	Water, acidulant malic acid INS 296, acidulant citric acid INS 330, black tea extract, concentrated lemon juice, flavoring (aroma identical to natural peach), acidity regulator: sodium citrate INS 331 iii, antioxidant ascorbic acid INS 300, artificial sweetener: aspartame INS 951 (10 mgs/100 ml) and acesulfame K INS 950 (8 mgs/100 ml) and sodium cyclamate INS 952 (22 mgs/100 ml)
Black tea lemon flavor (Lipton®, Ambev, Jaguariúna, Brazil)	Water, sugar, acidulant citric acid INS 330, black tea extract, concentrated lemon juice, flavoring (aroma identical to natural peach), acidity regulator: sodium citrate INS 331 iii, antioxidant ascorbic acid INS 330
Black tea lemon flavor (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	Water, sugar, black tea extract, acidulant citric and phosphoric acid, flavoring identical to natural, acidity regulator sodium citrate, preservative sodium benzoate and potassium sorbate, sequestrant sodium hexametaphosphate and dimethylpolysiloxane antifoam
Black tea peach flavor (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	Water, sugar, black tea extract, acidulant citric and phosphoric acid, synthetic aroma identical to natural, acidity regulator sodium citrate, preservative sodium benzoate and potassium sorbate, sequestrant sodium hexametaphosphate and dimethylpolysiloxane antifoam
Green tea (Feel Good, Wow Nutrition, São Bernardo do Campo, Brazil)	Water, green tea powder ( <i>Camellia sinensis</i> ), stabilizing sodium citrate, acidulant citric acid, antioxidant ascorbic acid (vitamin C), aroma identical to lemon natural, concentrated lemon juice and artificial sweetener sodium cyclamate (40 mgs/100 ml), sucralose (6 mgs/100 ml) and sodium saccharin (4 mgs/100 ml)
Black tea lemon flavor (Nestea, Nestlé, São Paulo, Brazil)	Water, sugar, black tea extract, acidulant citric and ascorbic acid, sequestrant sodium hexametaphosphate, preservative sodium benzoate and potassium sorbate, flavoring, caramel color and dimethylpolysiloxane antifoam
Black tea lighth peach flavor (Lipton®, Ambev, Jaguariúna, Brazil)	Water, acidulant malic acid INS 296, black tea extract, concentrated peach juice, flavoring (aroma identical to peach natural), preservative potassium sorbate INS 202, acidity regulator: sodium citrate INS 331 iii, antioxidant ascorbic acid INS 300, artificial sweetener: aspartame INS 951 (22 mgs/100 ml) and acesulfame K INS 950 (7,2 mgs/100 ml)
Natural mate tea (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	Water, mate extract, sugar, acidulant citric acid, antioxidant ascorbic acid, preservatives sodium benzoate and potassium sorbate

**Chart 2.** Composition of the brewed teas and yerba mate tested in this study, Porto Alegre (RS), 2011.

Tea's commercial brand (manufacturer)	Composition
Green tea (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	Leaves and stalks of green tea ( <i>Camellia sinensis</i> , <i>L. kuntze</i> )
Chamomile (Dr. Oetker Brasil, São Paulo, Brazil)	Chamomile ( <i>Matricaria recutita</i> ), floral chapters
Lemongrass (Prenda, Senador Salgado Filho, Brazil)	Leaves of lemongrass ( <i>Cymbopogon citratus</i> )
Black tea (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	Leaves and stalks of black tea ( <i>Camellia sinensis</i> <i>L. kuntze</i> )
Natural mate tea (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	Leaves and stalks of yerba mate toasted ( <i>Ilex paraguariensis</i> )
Boldo (Prenda, Senador Salgado Filho, Brazil)	Leaves of boldo ( <i>Pneumus boldus</i> , Molina)
Yerba mate (Seiva Pura®, Ijuí, Brazil)	Leaves and stalks of yerba mate ( <i>Ilex paraguariensis</i> )

## RESULTS

Table 1 shows the results of pH values and titratable acidity of ready to drink teas. Mean values of pH of ready to drink teas (canned and bottled) varied between 2.89 and 4.03. The smallest pH value (2.89) was found for a commercial brand of canned black tea with a lemon flavor. In regard to titratable acidity, ready to drink teas showed mean values varying between 3.77 ml and 12.68 ml. The tea which required the highest volume of NaOH solution to neutralize its pH was also a commercial brand of canned black tea with a lemon flavor.

**Table 1.** pH and titratable acidity values (mean  $\pm$  standard deviation) of each ready to drink tea analyzed in this study, Porto Alegre (RS), 2011.

Tea's commercial brand (manufacturer)	pH	Titratable acidity (ml)
Black tea zero lemon flavor (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	2.89 $\pm$ 0.02	11.05 $\pm$ 0.47
Black tea peach flavor (Nestea, Nestlé, São Paulo, Brazil)	2.99 $\pm$ 0.04	8.59 $\pm$ 0.32
Black tea peach flavor (Lipton®, Ambev, Jaguariúna, Brazil)	2.96 $\pm$ 0.04	8.73 $\pm$ 0.24
Black tea zero peach flavor (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	3.04 $\pm$ 0.04	7.99 $\pm$ 0.13
Black tea ligh lemon flavor (Lipton®, Ambev, Jaguariúna, Brazil)	3.41 $\pm$ 0.05	6.11 $\pm$ 0.29
Black tea lemon flavor (Lipton®, Ambev, Jaguariúna, Brazil)	3.13 $\pm$ 0.04	9.68 $\pm$ 0.39
Black tea lemon flavor (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	3.05 $\pm$ 0.02	11.85 $\pm$ 0.13
Black tea peach flavor (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	3.18 $\pm$ 0.03	7.54 $\pm$ 0.07
Green tea (Feel Good, Wow Nutrition, São Bernardo do Campo, Brazil)	3.60 $\pm$ 0.02	7.73 $\pm$ 0.09
Black tea lemon flavor (Nestea, Nestlé, São Paulo, Brazil)	2.90 $\pm$ 0.07	12.68 $\pm$ 0.40
Black tea ligh peach flavor (Lipton®, Ambev, Jaguariúna, Brazil)	3.39 $\pm$ 0.03	8.74 $\pm$ 0.05
Natural mate tea (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	4.03 $\pm$ 0.01	3.78 $\pm$ 0.06

Table 2 shows the pH values (mean and standard deviation) for the brewed teas and yerba mate. Mean values of pH for these teas varied between 6.75 and 7.89. The yerba mate prepared for *chimarrão* showed a mean value of 7.10. Since brewed tea and yerba mate showed pH neutral values (approximately pH 7.0), it was not possible measure their values for titratable acidity.

**Table 2.** pH values (mean  $\pm$  standard deviation) of each brewed tea and yerba mate analyzed in this study, Porto Alegre (RS), 2011.

Tea's commercial brand (manufacturer)	pH
Green tea (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	7.02 $\pm$ 0.05
Chamomile (Dr. Oetker Brasil, São Paulo, Brazil)	7.89 $\pm$ 0.03
Lemongrass (Prenda, Senador Salgado Filho, Brazil)	7.45 $\pm$ 0.09
Black tea (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	6.75 $\pm$ 0.11
Natural mate tea (Matte Leão, Coca Cola® Brasil, Rio de Janeiro, Brazil)	7.37 $\pm$ 0.01
Boldo (Prenda, Senador Salgado Filho, Brazil)	7.29 $\pm$ 0.08
Yerba mate (Seiva Pura®, Ijuí, Brazil)	7.10 $\pm$ 0.01

When comparing the type of tea, ready to drink teas showed a mean pH values significantly lower than brewed teas and yerba mate ( $p < 0.05$ ).

## DISCUSSION

Erosion lesions on enamel surface happen due to demineralization caused by subsaturated solutions in relation to hydroxyapatite and fluorapatite considering that the dissolution kinetic is associated to reactions controlled by the diffusivity degree of acids in solution<sup>21</sup>. One of the most important extrinsic factors in dental erosion is the high consumption of acidic beverages and foods. The consumed amount and the frequency of consumption of products containing acids have increased due to changes in life style<sup>22</sup>.

All brewed teas and yerba mate presented pH values close to neutrality, showing no erosive potential to teeth. This finding can be explained through the Stephan's report<sup>23</sup>, which did not observe loss of superficial hardness of teeth when they were in contact with teas without an acid component. In the present study, the water used to prepare the brewed teas and yerba mate showed a pH = 7.0. After beverage preparation, little variation in pH value was observed. This finding indicates that the water utilized for the preparation of brewed tea and yerba mate can be determinant for the final pH of these beverages.

The yerba mate (*Ilex paraguariensis*) is a natural product widely known and consumed in the southern region of Brazil, similarly in Paraguay, Uruguay and Argentina. In the southern region of Brazil it is consumed by the infusion of leaves, in a way called *chimarrão*,

characterized as one of the region's main cultural habits<sup>24</sup> which justify its inclusion in the study.

In relation to ready to drink teas, it was verified, in the present study, that they showed lower pH values, and higher values of titratable acidity compared to brewed teas and yerba mate. Ready to drink tea is submitted to an industrialization process in which other components are added to the tea. Among them there are acidulants. The addition of acidulants to the product causes a significant reduction of the beverage pH value. All pH values observed for ready to drink teas tested in this study were below 4.03.

When evaluating the erosive potential of a beverage there are other variables which can be considered such as calcium, fluoride and phosphorus concentrations and the type and concentration of acids present in the beverage. However, the major factor when analyzing the action of erosive beverages remains the pH value<sup>25-26</sup>.

The titratable acidity measurement has also been used to assess beverages' erosive potential. This method considers the type and concentration of the present acid. The majority of erosive beverages have weak acids and the concentration of these acids determines not only the pH value but also the buffering properties. Many authors have found a strong association between titratable acidity and erosive potential of beverages<sup>27-29</sup>. All ready to drink teas evaluated in this study showed the high titratable acidity values.

Analyzing the composition of ready to drink teas tested in the present study, it was found that most of them contained citric acid as the acidulant, be it associated or not to phosphoric acid. Citric acid has a high erosive potential due to its acidic nature and chelating properties<sup>30-31</sup>. This finding can justify the reduced pH values and high titratable acidity values found in ready to drink teas.

In the present study the green tea was analyzed in both forms ready to drink and brewed. The literature has reported many different properties of this tea against dental caries due to presence of their catechins<sup>32-33</sup>. Furthermore, green tea has components which can inhibit matrix metalloproteinase that are present on saliva and on mineralized dental tissues<sup>34</sup> decreasing the dental erosion/abrasion *in situ*<sup>35</sup>.

To determine the erosive potential of a beverage it is necessary to consider aspects other than pH and titratable acidity values, although results from these two factors can be used as indicators for this issue. Others studies are being conducting to evaluate the erosive potential of these teas on mineralized dental tissues, considering other variables involved.

## CONCLUSION

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The present study demonstrated that, among teas commercially available on the Brazilian market, ready to drink teas show lowest pH values and highest titratable acidity values compared to brewed teas tested. These findings suggest an erosive potential for this kind of tea.

## Collaborators

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LBL LUNKES was responsible for performance of the experimental phase, data analysis and writing the manuscript. LN HASHIZUME was responsible for conception the research project, planning, analysis and results interpretation and writing the manuscript.

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