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Physico-Chemical Characterization of *Ilex paraguariensis* St. Hil. During the Maturation

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ABSTRACT

In Brazil, yerba mate is consumed after processing; however, in Chile and Uruguay, the consumers prefer the cured product, which acquires a yellow color. For that yerba-mate is stored for a period of six months to one year, which increases the cost of the final product for the overseas market. This study evaluated the effect of humidity and temperature in maturation chamber on the time required for the product to get this characteristic. The changes in the color, pH, moisture and water activity were evaluated during the time of storage in different conditions of temperature and humidity. Yerba-mate subjected to higher temperature and humidity showed nearest color of the product submitted to natural storage. The loss of green color was related to the reduction in pH and increase in the moisture of the samples. The higher humidity allowed the mate to reach conditions near to market requirements abroad in approximately 60 days of maturation.

Key words: Yerba-mate, early maturation, color

INTRODUCTION

Yerba-mate (*Ilex paraguariensis* St. Hil) is a native species from South America cultivated in south of Brazil, Argentina, Paraguay and Uruguay (Hao et al. 2013). Brazil is responsible for 63.40% of world production and the biggest productive areas distributed between South and the estates of Mato Grosso do Sul and São Paulo (Gorenstein et al. 2007; Malheiros 2007). In some South America countries, the leaves and branches infusion is consumed like 'chimarrão', featured as a principal cultural habits.

Yerba-mate industrial processing involves different phases that can modify its chemical composition and change the flavor of the final product, consisting basically of three steps: roasting, drying and grinding (Isolabella et al. 2010; Valerga et al. 2012). During the roasting, the leaves and branches are exposed quickly to fire in a furnace to inactivate the enzymes, which cause oxidation of the product. The drying is done in two types of dryers, rotary dryer and belt dryer. In rotary dyer, smoke of the fire makes direct contact with the raw material, while in the belt dryer, there is no such contact, resulting, less damage to the raw material (Schmalko et al. 2005; Vieira et al. 2010).

The consumers priority of yerba-mate in Brazil is with a green color; however, in Chile and Uruguay

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they prefer the product with a yellow color (Valduga et al. 2003), which is due to the degradation of chlorophyll (Nabechima et al. 2014). To acquire this characteristic, milled yerba-mate is stored for six months to one year, which provides color and flavor of a matured product (Isolabella et al. 2010). However, the time of storage increases the costs of the product destined to export.

The methods for the measurement of color intensity include simple visual comparison with the standards or measure by colorimeters and spectrophotometers. The instrumental analysis to measure the color eliminate the subjective aspect of visual assessment (Savadkoohi et al. 2014). This work studied the colorimetric evaluation of yerba-mate processed samples on different drying systems with the aim to reduce the time of maturation.

METHODS

Samples of yerba-mate processed and vacuum packed for the traceability and from to different lots were obtained from Barão Yerba-Mate and Teas – Barão de Cotegipe/RS. The samples were submitted to different processing: (1) belt dryer – input 350 ºC, output 70ºC; (2) rotary dryer - 8 rpm, 90ºC; and (3) processing in a laboratory roaster with the use of liquefied petroleum gas with mass flow of $2.1 \cdot 10^{-4}$ $Kg \cdot s^{-1}$. (Valduga et al. 2003), followed by drying in a fixed bed dryer with hot air stream at 70°C. Samples were exposed to three systems of storage: environmental conditions of temperature and humidity, in maturation chamber at 40°C / 60% RH and 40°C / 90%RH. The colorimetric parameters obtained from the samples had as reference values measured in a yerba-mate sample meant for the export, which were storage for six months.

To evaluate quantitatively the changes produced by the storage, concomitantly with color the chlorophyll content of maturated and non-maturated yerba-mate samples was measured spectrophotometrically (Moran, 1982). The color was measured valuation by a colorimeter (Minolta CR 400), with CIELab system scales, where L^* represented the luminosity varying from 0 (black) to 100 (white) and parameters 'a^*' and 'b^*' colorimetric coordinates (-a = green, +a =red; -b = blue e +b = yellow), both ranging from -60 to +60. For moisture determination, 10 g of material was heated at 105°C for 3 h, cooled and weighed until constant mass. The water activity was determined with the apparatus Aqua-lab, model CX-2, at 25°C. The pH was measured in a 0.1 $g \cdot mL^{-1}$ solution using a digital potentiometer.

All the measurements were done in triplicate and the results were expressed as mean ± standard deviation. For means comparison *t* test or variance analysis ANOVA following the *Tukey* test were used and the level of significance adopted was 5% ($p<0.05$).

RESULTS

Drying system did not affect the standard of changes observed according to time for the parameters evaluated. For this reason, it was decided to describe just the behavior of these parameters in the samples processed on belt dryer. The colorimetric parameters of yerba-mate submitted to natural storage and non-matured yerba-mate are presented in Table 1, and same comparison to chlorophyll and pheophytins pigments concentration is presented in Figure 1.

Table 1 - Parameters L^*, a^* e b^* of yerba-mate sample submitted to natural storage.

Parameter	Matured yerba-mate	Non-matured yerba-mate	p value
Luminosity (L^*)	42.120 ± 2.207	45.803 ± 1.573	0.0186
Green color (a^*)	-1.908 ± 0.262	-8.693 ± 0.214	< 0.0001
Yellow color (b^*)	11.147 ± 0.808	20.097 ± 0.337	< 0.0001

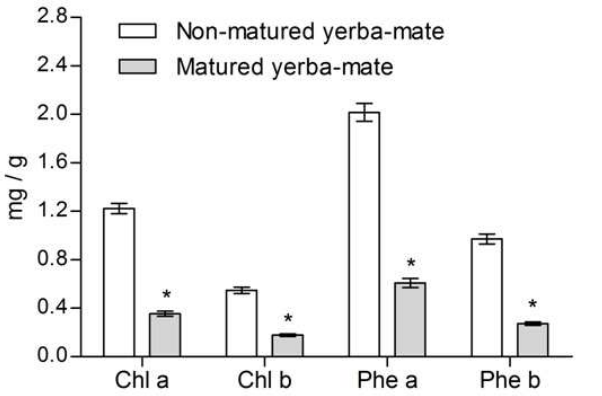

Figure 1 - Concentration of chlorophylls (Chl) and pheophytins (Phe) in non-matured and matured yerba-mate. (*) $p < 0.05$.

The measured values of the colorimetric coordinates for the matured yerba-mate were compared during the storage (Fig. 2). The

parameter a* in a chamber at 40°C / 60% RH showed no statistically significant differences in relation to yerba-mate naturally stored for 45 and 60 days. The samples in a chamber at 40°C / 90% RH didn't differ from the control at 30 days (Fig. 2A). The samples subjected to conditions 40ºC/90% RH showed no statistically significant differences in relation to the parameters b* and L* at 60 days of storage (Fig. 2B and 2C). In all samples there was a reduction in pH and an increase in moisture and water activity according to time. These changes were more pronounced under the conditions of high humidity of maturation chamber (Fig. 3). There was a correlation between the loss of green color with the variation of moisture and pH of the sample (Fig. 4). Such parameters could be important to characterize the product during the maturation process.

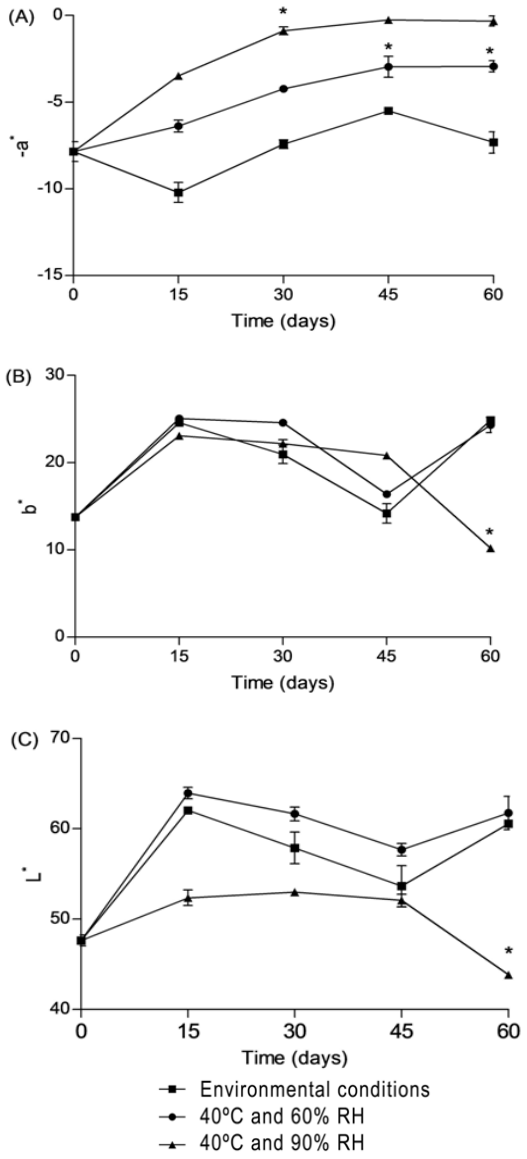

Figure 2 - Color variation according to time in different conditions of storage. The (*) indicates instants of storage that weren't observed differences statistically significant due to natural storage, following *Tukey* test with reliable 95%.

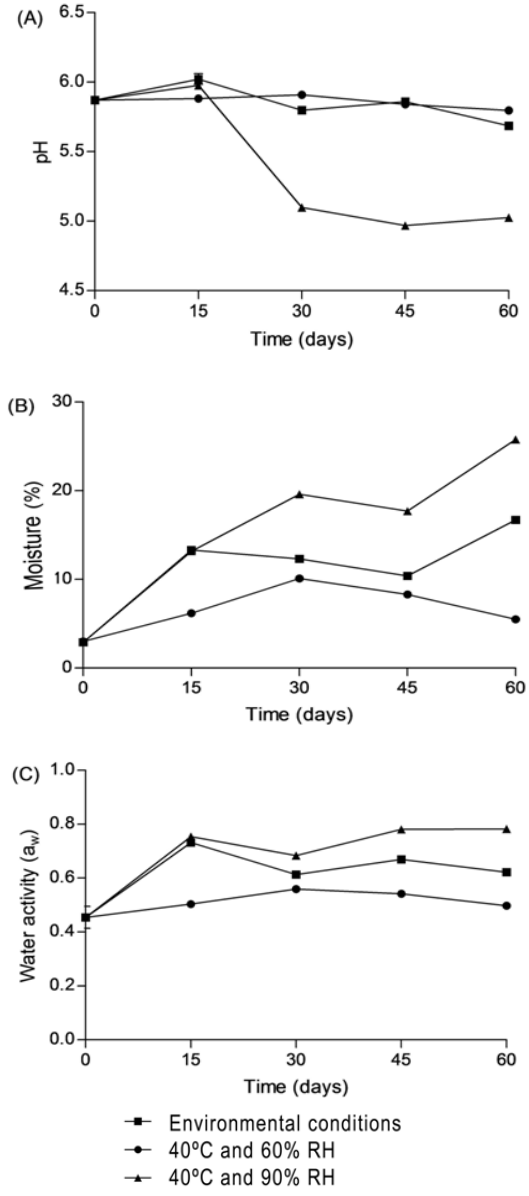

Figure 3 - Variation of pH, moisture and water activity according to time of samples exposure.

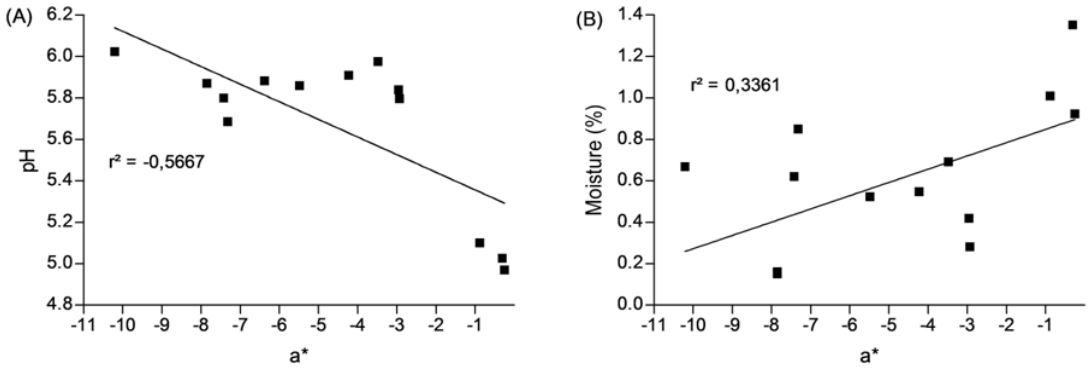

Figure 4 - Relation between parameters physico-chemicals analyzed and green color. In (A) correlation to pH (p = 0.0012) and in (B) of moisture (p = 0.0298) with green color degradation.

DISCUSSION

Other studies have demonstrated increased luminosity and yellowness concomitantly with the reduction of green color over the storage (Trela et al. 2011). In the present study, one of the trials was an exception to this behavior. The luminosity and yellow color between 45 and 60 days of storage in high humidity were reduced, possibly due to the high humidity. Studies have indicated that the loss of the yellow color in the shelf life is caused by the oxidation reactions (Malheiros 2007). The decrease in green color is due to chlorophyll degradation, which was more intense when the water activity was high (Schmalko and Alzamora 2005). The degradation of chlorophyll was also associated with a reduction in pH. Previous studies that evaluated the chlorophyll kinetics degradation in the peas demonstrated that its half-life was reduced at low pH and high temperature, adjusting to a first-order kinetic model (Koca et al. 2006). The decrease in the chlorophylls and pheophytins levels also was observed during the yerba-mate self-life (Malheiros 2007). Changes in the color also occurred during the shelf-life of yerba-mate. During 180 days, the parameters L *, a * and b * were measured each 30 days and varied significantly between the consecutive measurements (Santos 2004).The sensory attributes such as color, taste, aroma and appearance of a food contribute to its acceptability, showing varied standards depending on the consumer market.

CONCLUSION

High humidity yielded the product with the characteristics close to that required by the market after 60 days maturation, in which the colorimetric coordinate a* was the nearest of matured product. The green color degradation was associated with increased moisture and pH reduction.

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