Color change and force degradation of esthetic orthodontic elastic ligatures submitted to foods from the Amazonian diet

Alteração de cor e degradação de forças de ligaduras elásticas ortodônticas estéticas submetidas a alimentos da dieta amazonense

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ABSTRACT
The aim was to evaluate the color changes (ΔE*) and force degradation (FD) of esthetic elastic ligatures when submitted to foods from the Amazonian diet. 150 segments of elastics (n=10) (American Orthodontics - AO Orthoclassic - OC and Orthometric - OM) were divided to be submitted 2 times a day, for 1min each immersion, for 28 days, in one of the solutions: AI- açaí, CU- cupuaçu, TU- tucumã, RW- red wine and DW- distilled water (control). FD was evaluated using a universal testing machine and ΔE* by spectrophotometer. Qualitative analyses were performed by scanning electron microscopy (SEM). The readings were taken at the following times: T0 - initial, T1 - 24 hours, T2 - 14 and T3 - 28 days. The FD and ΔE* data were analyzed by non-parametric statistics ($p<0.05$). It was found that in the 3 brands, in all substances, there was a significant decrease in strength at T1 and at T2 there was an increase in strength. At T3, it is found that CU and DW promote significant differences from AI to OM and OC. For ΔE* it was verified after 28 days in OM the ΔE* was higher for the elastics submitted to TU and RW than in CU and DW. For OC, the variation was greater in DW than for TU and AI, whereas for AO there was no significant difference between the groups. for all brands there is a higher FD in the first 24 hours, with elastic recovery after this period; all solutions promote FD in the evaluated elastics and, for all brands tested, the ΔE* is clinically unacceptable after 28 days of immersion.

Keywords: Synthetic Elastic, Food, Staining, Degradation.

RESUMO
O objetivo foi avaliar a alterações de cor (ΔE*) e degradação de força (DF) de ligaduras elásticas estéticas quando submetidas a alimentos da dieta amazonense. 150 segmentos de elásticos (n=10) (American Orthodontics – AO Orthoclassic - OC e Orthometric – OM) foram divididos para serem submetidos 2 vezes ao dia, por 1min cada imersão, durante 28 dias, em uma das soluções: AI- açaí, CU- cupuaçu, TU- tucumã, VT- vinho tinto e AD- água destilada (controle). A DF foi avaliada por meio de máquina de ensaio universal e ΔE* por especrofotômetro. Foram realizadas análises qualitativas por meio de microscopia eletrônica de varredura (MEV). As leituras foram realizadas nos tempos: T0 – inicial, T1 - 24 horas, T2 - 14 e T3 - 28 dias. Os dados de DF e de ΔE* foram analisados por estatística não paramétrica ($p<0,05$). verificou-se que nas 3 marcas, em todas as substâncias, houve diminuição significativa da força em T1 e em T2 houve aumento da mesma. Em T3, verifica-se que CU e AD promovem diferenças significativas do AI para OM e OC. Para ΔE* verificou-se após 28 dias em OM o ΔE* foi maior para os elásticos submetidos ao TU e VT do que em CU e AD. Para OC a variação foi maior em AD do que para TU e AI, já para AO não houve diferença significativa entre os grupos. para todas as marcas há uma maior DF nas primeiras 24 horas, com recuperação elástica após esse período; todas as soluções promovem DF nos elásticos avaliados e, para todas as marcas testadas o ΔE* é clinicamente inaceitável após 28 dias de imersão.

Palavras-chave: Elástico Sintético, Alimentos, Coloração, Degradação.

1 INTRODUCTION

Synthetic elastic is one of the most used appliances in orthodontics today, due to its many advantages, among which the possibility of replacing metal ligatures, closing arches, open or closed springs, allowing the closure of spaces, correction of rotations and canine movement in distal direction (BALHOFF et al., 2011)0 below. Besides the ease of use, variety of colors, convenience, and patient acceptance (FERREIRA-NETO e CAETANO, 2004).

Regarding coloration, there has been a considerable increase in the use of transparent elastics (Crystal), particularly due to treatments of adult patients and the demand for aesthetic orthodontic appliances (KAWABATA et al., 2016; BARTH et al., 2018). However, this component is subject to color change by foods with high pigmentation potential, resulting in an aesthetic problem compared to ceramic brackets that are more resistant to color change (DA SILVA et al., 2016; KAWABATA et al., 2016).

The concern about the behavior of these elastics is relatively old (HUGET et al.,1990) and remains constant (ALDREES et al., 2015; NAKHAEI et al., 2017; MENON et al., 2019). With strength degradation and the influence of pigmentation on aesthetic orthodontic elastic ligatures being two of the biggest concerns today (FERNANDES et al., 2012). The color change in orthodontic elastomer is caused by endogenous factors (FERNANDES et al., 2012), i.e., referring to the intrinsic characteristics of the material and exogenous factors, such as foods containing pigments, beverages (red wine), mouth rinses (HUGET et al., 1990; DIETSCHI et al., 1994; FERNANDES et al., 2012), besides also being sensitive to prolonged exposure to water and saliva that promotes the weakening of the intermolecular strength of the elements (KOCHENBORGER et al., 2011).

In this regard, several types of foods have a high pigmentation or acidification content, especially some fruits found in the northern region of Brazil. Due to the fact that a great diversity of natural foods can be found, the diet of the northern population is based on fruits, or nectar extracted for daily consumption (BRASIL, 2002). Among these commonly used foods are *Astrocaryum tucumã martius* (tucumã), *Euterpe oleracea* (açaí) and *Theobroma grandiflorum* (cupuaçu) which are consumed by almost the entire population of the Amazon region.

Besides the potential for staining that these substances may present, their chemical compositions can cause changes in the strength of orthodontic elastics, i.e., there may be an early decrease in strength, which may lead to future problems for patients, such as increased treatment time and/or loss of aesthetics during the period between consultations (ZIUCHKOVSK et al., 2008; MACÊDO et al., 2012, DE AGUIAR et al., 2014).

Several studies (KOCHENBORGER et al., 2011; FERNANDES et al., 2012; ALDRESS et al., 2015) in the literature, which verified degradation of forces and change in color of chain elastics, focused on the evaluation of colored elastics, however, there is an increasing demand for invisible appliances, which justifies the study of aesthetic elastics. Added to this, the development of new elastics on the market with characteristics that, according to manufacturers, promote greater strength, have raised possibilities for new studies in the area, seeking better materials, shorter treatment time and greater patient comfort (FERNANDES et al., 2012). In addition, there are regional differences in food that can provide a greater or lesser degree of staining of dental appliances (BEATTIE and MONAGHAN, 2004; DA SILVA et al., 2016).

In this sense, no articles were found that verified the staining and/or the degradation of the strength of aesthetic chain elastics promoted by Amazonian food.

Thus, aiming at the physicochemical characteristics of foods, in face of the limitations of the literature in evaluating the degradation of strength and staining under the influence of chemical reactions present in certain foods, the present study evaluated the effect of Tucumã, Açaí and Cupuaçu, on the strength, coloration and surface characteristics of new aesthetic chain elastics when compared to foods frequently studied in the literature.

The null hypothesis of this study is that there will not be greater staining and strength degradation when such substances from the Amazonian diet are used. Therefore, the aim of this study was to evaluate the color change and strength degradation of aesthetic elastic bandages when subjected to foods from the Amazonian diet as a function of time.

2 MATERIAL AND METHODS

Experimental planning

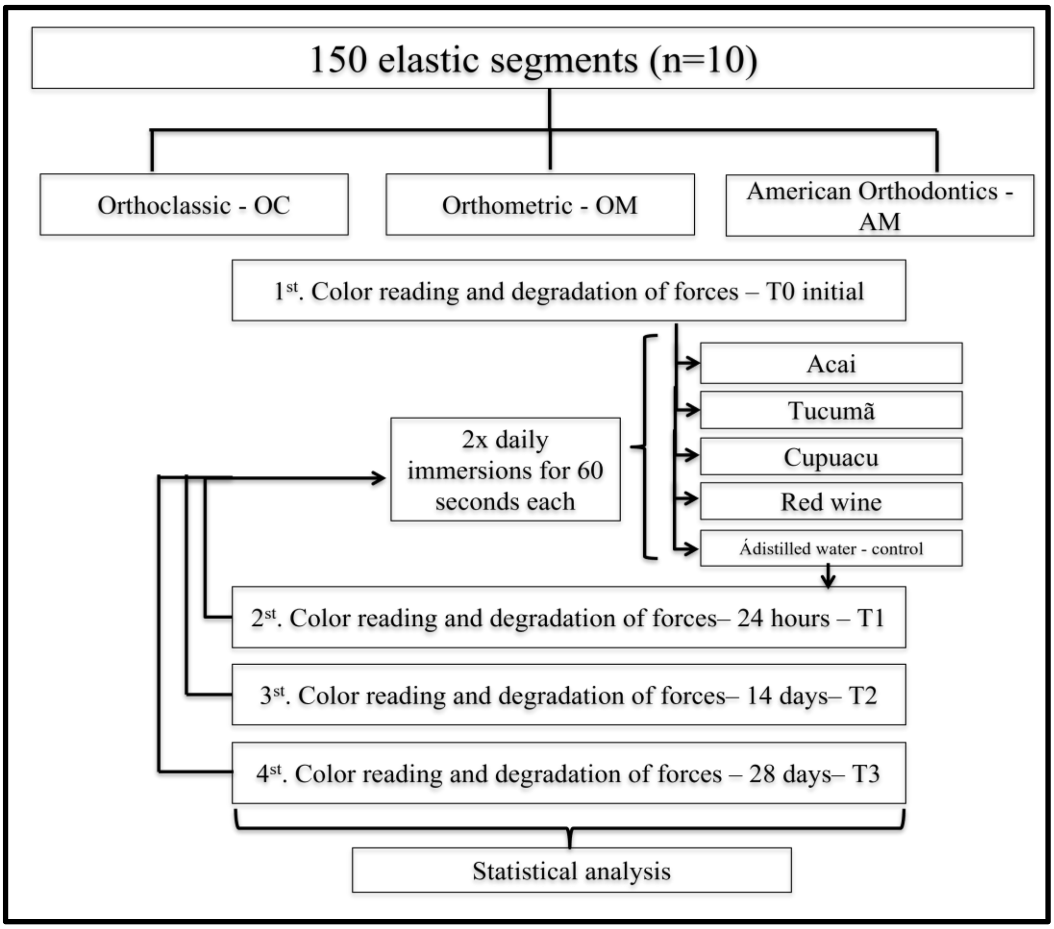
A pilot plan was conducted to determine the number of specimens for each experimental condition. The sample number was 330 segments of chain elastics that had the same force pattern. The remaining 150 (n=10) segments were used for color change and force degradation tests, and the remaining 180 (n=3) were used for scanning electron microscopy (SEM) analysis. The elastics from each experimental group were mounted on separate acrylic plates (11 x 4 cm).

The factors under study were the dietary factor, orthodontic elastics and reading time. We evaluated 3 brands of orthodontic elastics (Orthoclassic - OrthoClassic INC., McMinnville, Oregon, USA; Orthometric - Industry and Commerce of Medical and Dental Products Ltd., Marilia, Sao Paulo, Brazil; American Orthodontics - Sheboygan, Wisconsin, USA) and 5 dietary factors (acai, tucumã, cupuaçu, red wine and distilled water - control).

The response variables were force degradation, color change and qualitative analysis of the surface of the elastics. These were obtained with the aid of the EMIC 23-200 universal testing machine, the SP62S spectrophotometer with QA Master I software model and the Scanning Electron Microscope (JSM 5410, Jeol, Tokyo, Japan), respectively.

Readings were taken in the initial period (T0), after 24 hours (T1), 14 (T2) and 28 days (T3). After the first reading, the plates with the esthetic elastic bandages were kept immersed in distilled water at 37ºC in an incubator (bacteriological model TE 392/2) during the entire experiment, being removed only at the time of the readings and the immersions in the potentially coloring solutions that occurred twice a day for 60 seconds for 28 days (Figure 1).

Figure 1. Experiment Flowchart.



Fabrication of specimens

The ligatures for the experiment were purchased in sealed packages and complied with the manufacturer's expiration date. For the test, 15 transparent acrylic resin plates were made (Mr.Jumar, Manaus/AM, Brazil) 11 cm long, 4 cm wide and 1 cm thick, with pins fixed at a standardized distance of 15 mm (LARRABEE et al., 2012).

15 acrylic plates were divided into 3 groups, each group containing 5 plates, according to the brand of elastic in study. Subsequently, the plates were subdivided according to the solutions used (Figure 2).

Initially, chain elastics segments were measured using a caliper (Mitutoyo Corporation, Tokyo, Japan) and subjected to 50% distension of their original length before being fixed on their respective plates, since pre-stretching of chain elastics can modify their behavior (DE AGUIAR et al., 2014). The long size aesthetic chain ligatures were fixed on the acrylic plates in a standardized manner (Figure 1).

Immersion in the solutions

After the initial readings, the end of the rubber band was removed from the Universal Testing Machine and the color apparatus and taken to its seating pin, at a distance equivalent to 15mm, on the respective acrylic plates. The plates with the elastics from each group were kept immersed in distilled water at 37°C throughout the experiment. Each plate containing the elastics was totally immersed in the substance corresponding to its group, following a methodology adapted from KOCHENBORGER et al. (2011), twice a day for 60 seconds each immersion, respecting a 12-hour interval between each immersion, except for the control groups, which remained submerged in distilled water.

After each immersion in the food, the plates were rinsed with distilled water and returned to their containers containing distilled water.

The pH of the solutions was checked whenever they were changed each day. The solutions were prepared according to table 1.

Table 1. Test solutions and its characteristics.

Solution	Manufacturer	Ingredients	Directions according to the manufacturer	pH
Açaí	Açaí pulp (Amazônia polpas-Manaus-AM)	Whole açaí pulp, ascorbic acid INS 300 (antioxidant) and citric acid INS (acidulant).	Solution prepared with 100gm of açaí pulp for 200 ml of distilled water. As directed by the manufacturer.	5,37
Cupuaçu	Fruit pulp in nature	Cupuaçu whole pulp, INS 300 ascorbic acid (antioxidant) and INS citric acid (acidulant).	Solution prepared with 100g cupuaçu pulp to 200ml distilled water. According to the Manufacturer.	6,2
Tucumã	Fruit pulp in nature	Pulp 100 grams equals 52,000 units of vitamin A or ten citrus fruits, vitamin C providing 247 calories.	Solution prepared with 100g of tucuma pulp in 200ml of distilled water. According to the manufacturer.	5,2
Red Wine	Quinta do Mogarmo red wine	Grapes, yeast, stabilizer	Alcoholic Fermentation	3,6
Distilled Water	ASFER	Pure, salt-free.	Distillation	7,0

Force degradation analysis

The force measurements were obtained by a single examiner. Each elastic segment was carefully transferred to the test mounted in the universal testing machine EMIC model 23-200, in the sequence in which the elastics were mounted on the acrylic plates. For this, the universal testing machine was prepared with two hooks, one facing up and one facing down, so that the elastics were held by them (Figure 2). In the universal testing machine, the elastics were subjected to a 20 mm stretch at a speed of 5 mm/min (LOSITO, 2014)[0]. Readings were taken at the initial period (T0), after 24 hours (T1), 14 (T2) and 28 days (T3).

Figure 2. Hooks adapted to the universal testing machine to take readings.

Color Change Analysis

The samples were subjected to color analysis using the X-Rite model SP62S spectrophotometer with QA Master Model software, following the methodology adapted from ALDREES et al. (2015). Readings were taken immediately after each strength degradation reading. With the aid of Mathieu forceps (GAC orthomax, Matão-SP, Brazil) and procedure gloves, the elastomeric chains were manipulated and supported on a white color surface, following a reading pattern, avoiding interferences from the background color.

The spectrophotometer used in the experiment has a focal aperture of 4 mm and a diffuse geometry of D/8°, and analyzes the spectra focused on the object using the CIE system, which uses three parameters for the definition of color, namely brightness, hue, and saturation (COMISSION INTERNATIONALE DE LECLAIRAGE, 1978).

The brightness referred to the degree of lightness and darkness of the object represented by the value of L*, L* = 100 equivalent to white and L* = 0 for black. The chromatic scale, called "hue" is represented by red if +a* and green if - a*, yellow if +b* and blue if -b* (Schulze et al., 2003)[0]. Saturation is the intensity of the hue and is given by the numerical value of a* and b*. The values of ΔL*, Δa*, Δb*, correspond to the difference in the values of L*, a*, b*, respectively, compared to the initial standard. Following the method proposed by SCHULZE et al. (2003).

Using the CIE color system L* a* b* color measurements were obtained. The ΔE* refers to the initial and final difference between two color stimuli which was calculated by the following formula: $\Delta E^* = \sqrt{(\Delta L^*)^2+(\Delta a^*)^2+(\Delta b^*)^2}$ (SCHULZE et al., 2003).

Scanning Electron Microscopy

Scanning electron microscopy (SEM) analyses were performed on a JSM 5410 Scanning Electron Microscope (Jeol, Tokyo, Japan) at a voltage of 15 kV. Three specimens were made for each experimental situation totaling 180 segments of elastic ligature to be subjected to scanning electron microscopy (SEM) analysis (Shirozaki et al., 2017)[0]. After treatment of the elastic bandage with the dye solutions, the material was mixed with a 1% Osmium Tetroxide solution for a period of 2 to 3 hours. The rubber band was then progressively dehydrated at concentrations of 10%, 30%, 50%, 70%, 80%, 90%, 95% to 100% ethanol for 10 minutes. The 100% ethanol was changed three times, the last time no more than 1h before it reached the critical point. For scanning electron microscope analysis, the specimens were dried in an EMS 850 device using CO2 and mounted on metal stubs with adhesive tape and conductive silver glue. The specimens were then gold plated for 60 seconds using a Denton Table II vacuum device (SHIROZAKI et al., 2017).

Methodology for analyzing the results

The strength degradation data were analyzed by generalized linear models for repeated measures in time, and the variations in color (ΔE*) were analyzed by mixed models for repeated measures in time. The data obtained were analyzed in the R program with a significance level of 5%.

3 RESULTS

Table 1 shows the percentages of change in degradation over time.

It was observed that after 24 hours of immersion there was a decrease in strength compared to the initial time, and for the Orthometric and Ortho Classic brands, there was no significant difference between groups regarding this variation ($p>0.05$). For the American Orthodontics brand, the variation in degradation at 24 hours was significantly greater for the group submitted to tucumã and distilled water than when submitted to açaí ($p<0.05$).

After 14 days of immersion, there was also no significant difference between the groups for the Orthometric and Ortho Classic brands regarding the variation in degradation in relation to the time of 24 hours ($p>0.05$), with an increase in strength in all groups. For American Orthodontics, the variation was significantly greater when submitted to distilled water than when submitted to tucumã, açaí and cupuaçu ($p<0.05$).

At the final time, that is, at 28 days of immersion, the variation in strength compared to 14 days for the Orthometric brand was significantly greater when submitted to açaí than when submitted to cupuaçu and distilled water ($p<0.05$). For Ortho Classic, the variation was significantly greater when submitted to cupuaçu and distilled water than to tucumã ($p<0.05$). For American Orthodontics, there was no significant difference between groups ($p>0.05$).

Table 1. Median (minimum value; maximum value) of the percentage of change in force degradation (%), in relation to the previous time, of aesthetic elastic bandages as a function of brand, immersion solution and time.

Brand	Solution	Time		
		24 hours	14 days	28 days
Orthometric	Tucumã	-30,66 (-40,44; -14,07) Ba	1,55 (-4,88; 24,82) Aa	5,60 (-1,84; 18,67) Aab
	Red wine	-31,67 (-43,05; -24,59) Ba	6,10 (-11,24; 17,58) Aa	5,40 (-3,69; 19,45) Aab
	Açaí	-33,40 (-37,87; -27,05) Ba	0,55 (-9,07; 16,16) Aa	7,57 (1,89; 18,74) Aa
	Cupuaçu	-31,20 (-34,41; -22,14) Ba	6,35 (-10,62; 23,55) Aa	1,78 (-13,52; 14,47) Ab
	Distilled water	-27,74 (-37,77; -21,68) Ba	6,27 (-11,58; 29,68) Aa	0,68 (-14,10; 16,40) Ab
Ortho Classic	Tucumã	*-42,37 (-45,89; -33,61) Ba	*15,08 (3,62; 21,30) Aa	0,42 (-10,58; 25,82) Ab
	Red Wine	-41,62 (-47,18; -35,79) Ba	11,49 (1,31; 20,52) Aa	4,45 (-12,75; 11,65) Aab
	Açaí	*-43,50 (-51,19; -30,18) Ba	*7,73 (2,19; 23,16) Aa	*-4,41 (-16,09; 21,96) Ab
	Cupuaçu	*-42,81 (-49,54; -31,58) Ba	11,97 (-2,02; 20,03) Aa	15,11 (-10,31; 33,38) Aa
	Distilled water	*-42,21 (-51,92; -26,71) Ba	11,04 (-14,71; 31,45) Aa	8,59 (3,13; 43,55) Aa
American Orthodontics	Tucumã	$*-51,80 (-54,42; -46,75) Bb	$-1,73 (-17,14; 22,57) Ac	$17,01 (-0,14; 36,91) Aa
	Red Wine	$*-49,63 (-50,59; -47,42) Bab	*16,44 (-1,15; 29,80) Aab	4,84 (-13,75; 18,62) Aa
	Açaí	*-47,64 (-50,04; -43,10) Ba	8,25 (-12,58; 14,38) Ac	$4,85 (-0,61; 38,96) Aa
	Cupuaçu	$*-48,14 (-52,45; -46,51) Bab	11,96 (0,17; 16,15) Abc	3,39 (-11,21; 20,96) Aa
	Distilled water	$*-50,41 (-55,30; -44,89) Bb	16,60 (13,10; 22,59) Aa	3,50 (-10,57; 14,72) Aba

*Differences from Orthometric (under the same solution conditions and time), $p \leq 0.05$.

Differs from Ortho Classic (under the same conditions of solution and time), $p \leq 0.05$. Medians followed by distinct letters (upper case horizontally and lower case vertically comparing solutions in each brand) differ from each other ($p \leq 0.05$).

The variation in color after immersion of the bandages in the solutions is presented in Table 2. It is observed that, after 24 hours of immersion, for Orthometric, the variation in color was significantly greater when submitted to tucumã, red wine and açaí ($p<0.05$). For Ortho Classic, the variation in color was significantly greater when submitted to red wine, cupuaçu and distilled water ($p<0.05$). And for American Orthodontics, there was no significant difference between the solutions ($p>0.05$). At the final time, 28 days of immersion, there was no significant difference between the solutions ($p>0.05$).

Table 2. Mean (standard deviation) color change (ΔE*) of aesthetic elastic bandages as a function of brand, immersion solution, and time.

Brand	Solution	Time		
		24 horas	14 dias	28 dias
Orthometric	Tucumã	6,05 (2,06) Ba	11,59 (1,76) Aa	7,97 (1,64) Ba
	Red Wine	6,39 (1,48) Aa	5,03 (1,26) Ab	7,62 (1,22) Aa
	Açaí	4,86 (2,11) Bab	5,21 (1,18) Bb	8,68 (1,53) Aa
	Cupuaçu	3,01 (1,31) Bb	6,92 (2,14) Ab	7,33 (1,91) Aa
	Distilled water	2,50 (1,89) Bb	5,85 (0,71) Ab	7,18 (1,04) Aa
Ortho Classic	Tucumã	2,98 (1,00) Bb	*6,07 (1,79) Aa	7,44 (1,69) Aa
	Red Wine	4,21 (1,62) Aab	5,25 (1,46) Aa	6,72 (1,57) Aa
	Açaí	3,18 (1,64) Bb	4,70 (1,27) ABa	6,96 (2,05) Aa
	Cupuaçu	3,55 (1,12) Bab	5,99 (1,32) ABa	7,13 (1,26) Aa
	Distilled water	*6,17 (0,93) Aa	6,12 (0,90) Aa	6,64 (1,64) Aa
American Orthodontics	Tucumã	4,46 (2,43) Ba	8,73 (2,05) Aa	8,21 (1,55) Aa
	Red Wine	3,93 (2,06) Ba	7,44 (0,91) Aa	7,59 (1,24) Aa
	Açaí	2,49 (1,29) Ba	5,89 (1,19) Aa	7,83 (2,39) Aa
	Cupuaçu	3,64 (1,81) Ba	6,40 (1,68) ABa	6,99 (2,16) Aa
	Distilled water	4,84 (2,58) Ba	5,89 (1,18) ABa	7,73 (1,90) Aa

*Differs from Orthometric (under the same solution conditions and time), $p \leq 0.05$. Averages followed by different letters (upper case in horizontal and lower case in vertical comparing solution in each brand) differ from each other ($p \leq 0.05$).

The structures of the elastic ligatures were qualitatively evaluated using scanning electron microscopy (SEM) and the results are seen in Figures 3 and 4 for Orthometric, Figures 5 and 6 Ortho Classic for and Figures 7 and 8 for American Orthodontics. The samples are observed in two magnifications (20x and 500x) when evaluated over time: 24 hours, 14 days, 28 days when subjected to treatments with açaí, tucumã, cupuaçu, red wine and distilled water.

Figure 3. Scanning electron microscope (SEM) analysis at 20x magnification of the Orthometric elastics.

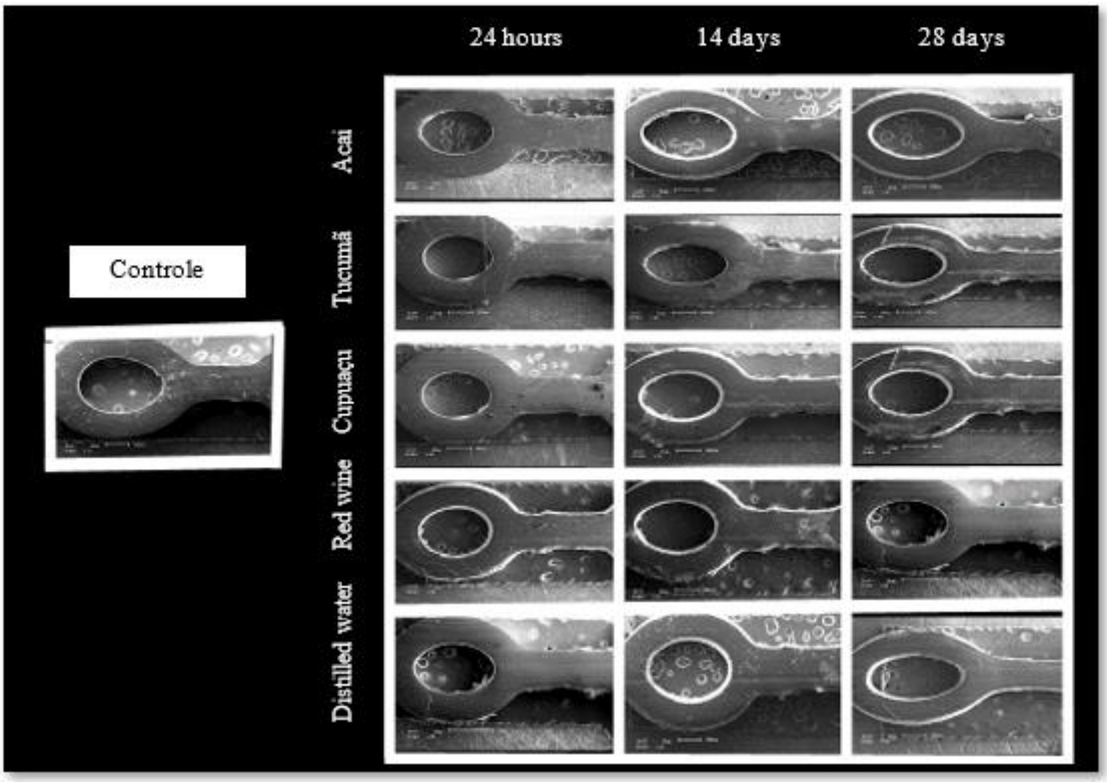
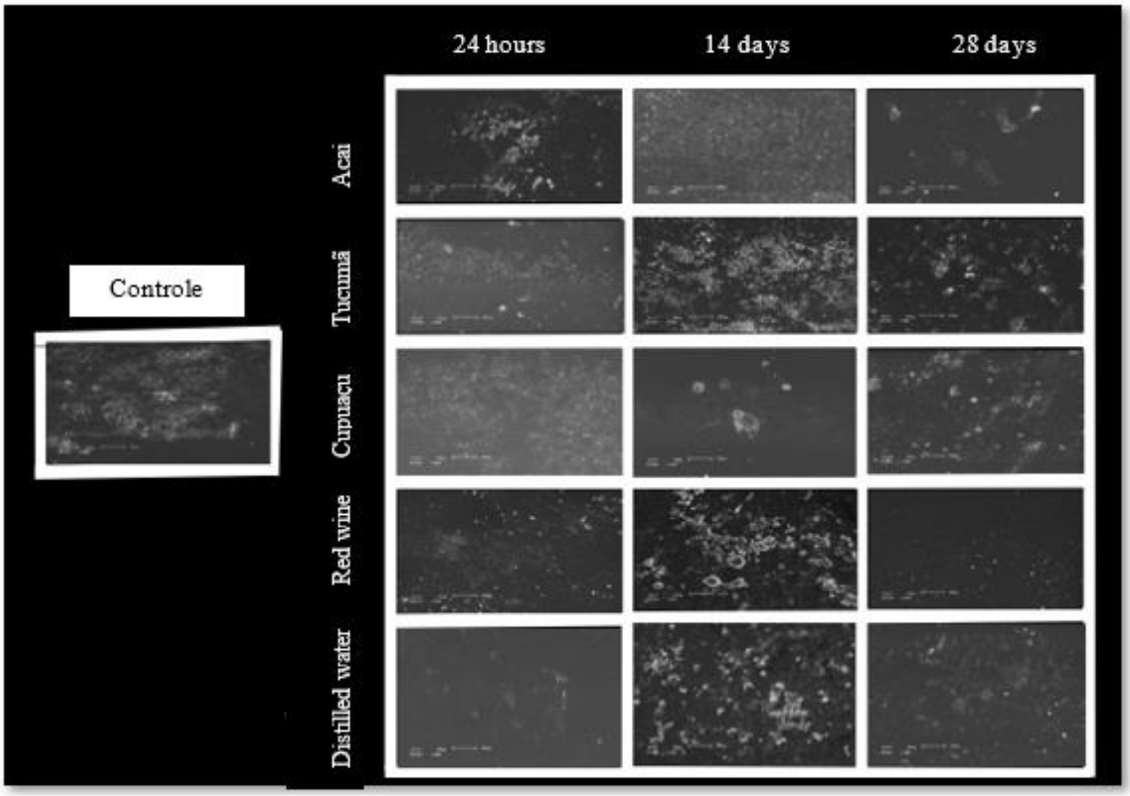


Figure 4. Scanning electron microscope (SEM) analysis at 500x magnification of the Orthometric elastics.



In Figure 3, it is visualized the samples of the elastic ligatures of the Orthometric brand (OM), it is verified that all the elastic submitted presented deformation over time. Figure 4 shows that the elastic submitted to distilled water and cupuaçu at 28 days presented a surface similar to each other and, at the same time, the elastic submitted to açaí presented a more homogeneous surface.

Figure 5. Scanning electron microscope (SEM) analysis at 20x magnification of the Orthoclassic elastics.

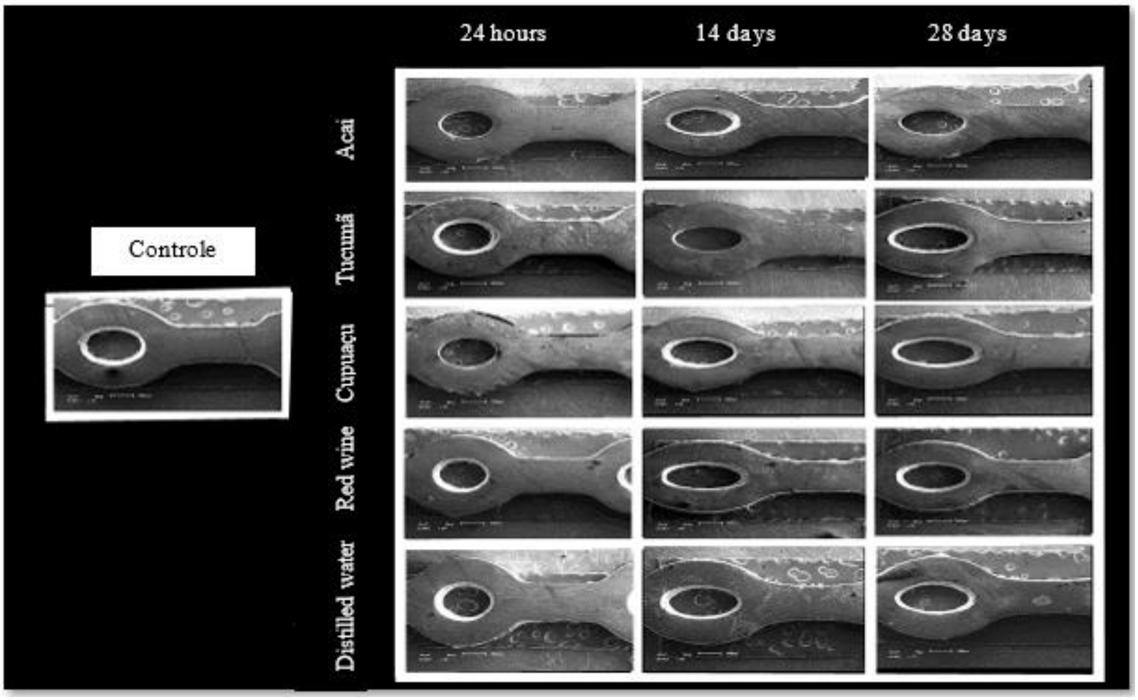


Figure 6. Scanning electron microscope (SEM) analysis at 500x magnification of the Orthoclassic elastics.

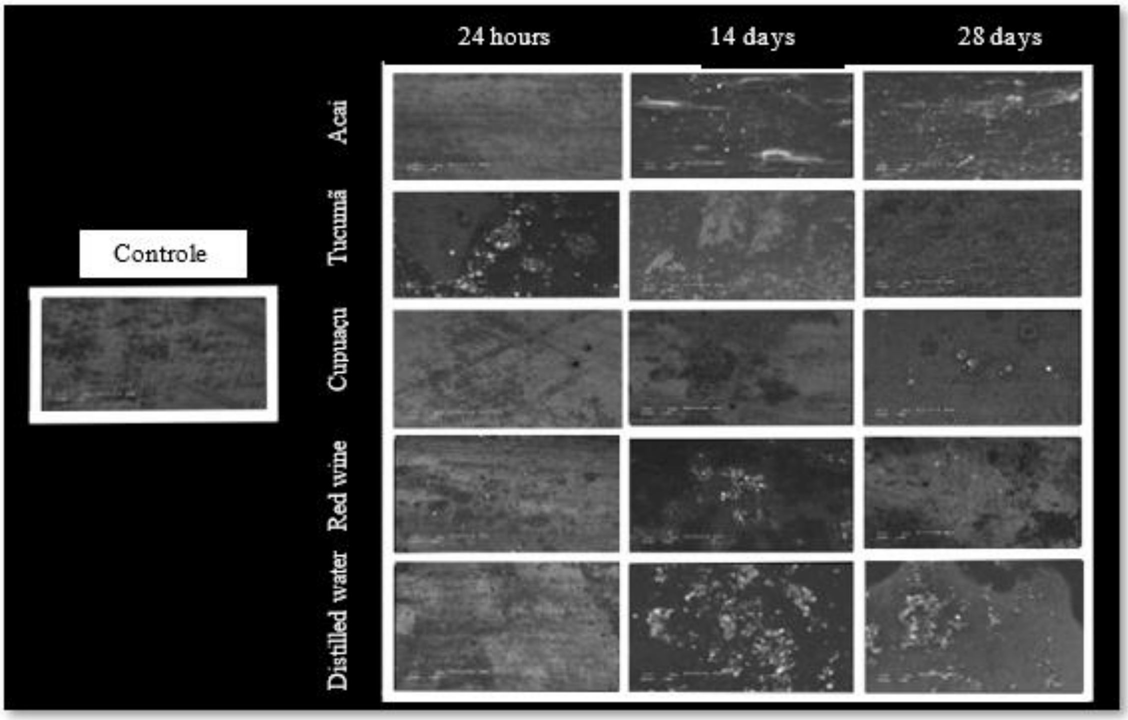


Figure 5 shows that apparently there is an increase in volume of the Ortho Classic elastics in the first 24 hours of immersion, when compared to the control, and there is a deformation of the links, especially after 14 and 28 days, but they are relatively similar for all groups of solutions. It can also be seen that apparently the thickness of the edges of the links remains close to that of the control group. Figure 6 shows that the elastic submitted to cupuaçu over time showed a more homogeneous surface than the others, with a smoother surface at 28 days than at the other two times.

Figure 7. Analysis using a 20x magnification scanning electron microscope from American Orthodontics.

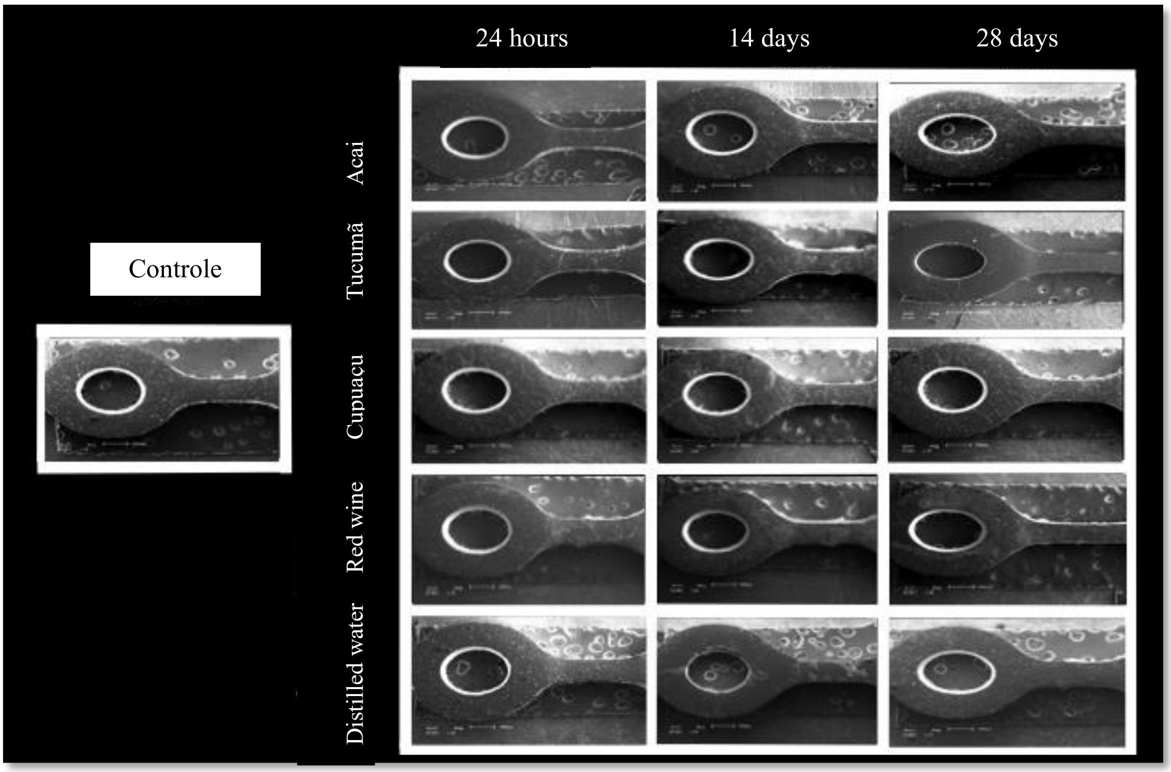


Figure 8. Analysis using a 500x magnification scanning electron microscope (SEM) from American Orthodontics

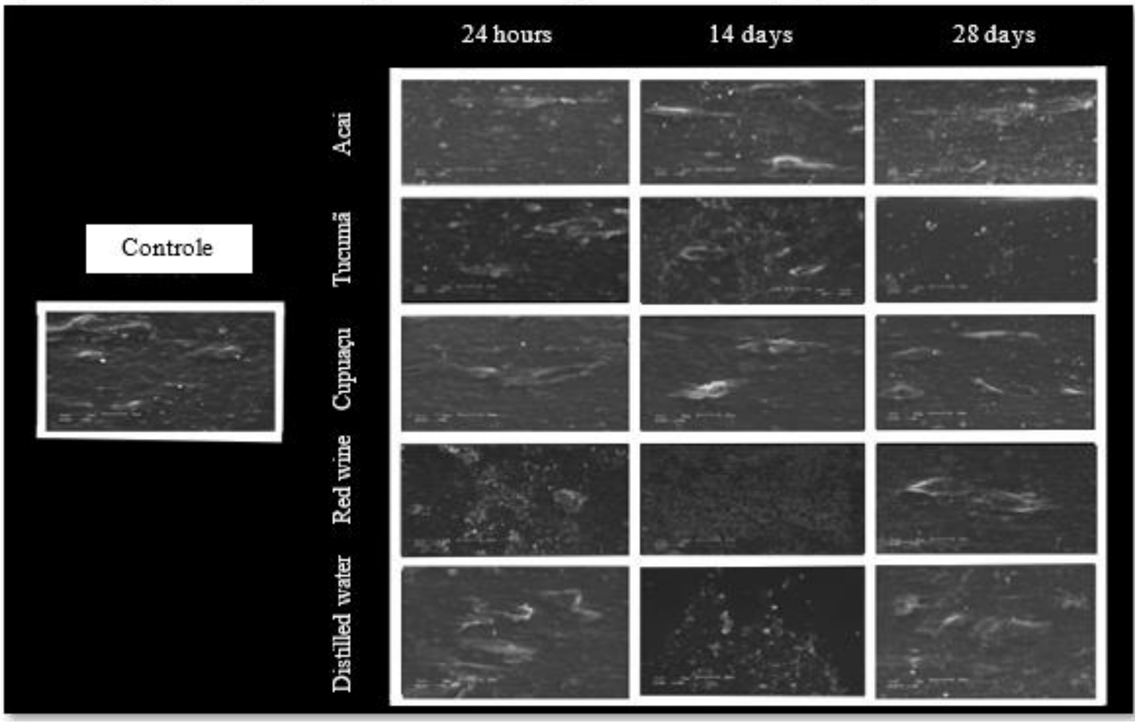


Figure 7 shows the results for the American Orthodontics (AO) elastic ligatures over 28 days. It can be observed that there was a deformation of the link, however, it remained stable over time, also verifying that the link thickness did not change in relation to the first 24 hours. A similar surface is also observed (Figure 8) for all solution groups at 28 days.

4 DISCUSSION

The use of aesthetic elastic ligatures has been of utmost importance in obtaining satisfactory results in orthodontic treatment.

Several works (ASH and NIKOLAI, 1978; NATTRASS et al., 1998; BEATTIE and MONAGHAN, 2004; TEIXEIRA et al., 2008; LARRABEE et al., 2012; LEÃO FILHO et al., 2013; PITHON et al., 2014; BEHNAZ et al, 2017) studied the influence of environmental factors (the environment in which the materials are found) on force degradation in different types of elastic materials in vitro, however, none of the studies found verified the action of fruits originating from the Amazon, which are currently widely consumed throughout the world. Regarding orthodontic chain elastics, no force degradation studies were found for the Ortho Classic elastic, recently developed by the industry, which, according to the manufacturer, has the advantage of being interchangeable after a longer period of use.

This study demonstrated that in the three brands studied there was a degradation of force after 24 hours of exposure to the different groups of solutions, with an average of 30.9% for the Orthometric group, 42.5% for Ortho Classic, and 49.5% for American Orthodontics. Such a result is similar to that of several studies that showed that there is force degradation after 24 hours of installing the elastomeric chains (ANDREASE and BISHARA, 1970; WONG,1976; ASH and NIKOLAI, 1978; KUSTER, INGERVALL and BURGIN, 1986; FERRITER, MEYERS and LORTON, 1990; LU et al., 1993; NATTRASS et al., 1998; ALDREES et al., 2015).

According to HALIMI et al. (2012), the permanent deformation observed in Figures 3, 5 and 7 and the degradation of the forces generated, initially, may occur due to the absorption of liquids from the environment, as well as due to temperature changes. Both situations occurred in this study, since the elastic bands initially had their readings taken as received by the manufacturers and then were placed in water and kept at a temperature of 37ºC, i.e., this possibly generated the force degradation of the first 24 hours (HALIMI et al., 2012).

All the brands used in this study also showed an increase in the force exerted by the elastics after 24 hours. Figures 4 and 6 also show that, when the time of 28 days is evaluated, the elastics that numerically presented greater elastic recovery also presented more uniform surfaces. These findings agree with the studies of LIU et al. (1993). Thus, this elastic recovery may have resulted from a time-dependent structural reorganization of the elastics (LIU et al., 1993). The study by LIU et al. (1993) demonstrated in their results that the increase in force occurred within the first 3 hours of stretching, whereas the recovery of force found in this study occurred mainly after 14 days of the beginning of the experiment. However, no intermediate time periods (between 24 hours and 14 days) were evaluated to verify if this elastic recovery occurs before 14 days.

This phenomenon may be due, according to Nattrass, IRELAND and SHERRIFF (1998) to the absorption of the immersion medium by the elastics, thus increasing the hardness of the elastics and altering the forces measured.

In this study, it was verified that for both Orthometric and Ortho Classic there was no statistically significant difference in the degradation of force for the different solutions used up to 14 days of immersion. It was found that at 28 days açaí was the substance for both brands that showed a statistically significant difference when compared to distilled water. No other studies were found that used acai to evaluate orthodontic elastics, allowing us to make comparisons with the literature.

However, when the time of 28 days was evaluated it was found that the findings of this study may be related to the binomial type of elastic and pH of the substances, since it can be seen that for the Orthometric elastic the two substances with the highest pH (distilled water and cupuaçu) promoted less change in force, while these same substances for the Ortho Classic elastic promoted greater change in force and for the American Orthodontics elastic there was no statistically significant difference between the groups. ADREASE and BISHARA (1970) assert that pH, exposure to light, air, water and other oxidizing agents, enzymes, food, and chemicals can alter elastic characteristics.

It was also found in the present study that the force degradation was different for each brand studied, which agrees with the work of KOCHENBORGER et al. (2011). The researchers studied 4 elastic bandages of different commercial brands and identified statistically significant differences regarding the mean stresses generated by the elastics as a function of time studied (KOCHENBORGER et al., 2011).

According to DE AGUIAR et al. (2014), what defines the speed and amount of force degradation that these materials will undergo when stretched in the oral environment is related to the technologies employed to manufacture the elastic chains and the materials used.

The chemical compositions of the current elastic chains may also influence the results of this work, as they vary according to the manufacturer. However, they keep the composition secret for commercial reasons. However, it is known that the main chemical compound is polyurethane and that its synthesis mechanisms are responsible for the variations in the properties of the materials.

Thus, it can be observed that the percentage of degradation in each food group is time-dependent and material-dependent. This implied that some food groups showed statistically significant differences between each other for a certain time, but at a later time, they no longer showed such a difference. Such a phenomenon was observed by LARRABEE et al. (2012)[0] and LIU et al. (1993)[0], who hypothesized that the differences observed between the study groups are a function of the variation in the manufacturing of the elastics used, since the authors kept the pH, temperature, and exposure time of the solution groups under control.

The color of the esthetic elastics was also evaluated, since the choice of an esthetic material with greater color stability is a factor that should be considered when choosing the elastic ligatures by the orthodontist (SILVA, 2008)[0].

The results of the color change experiments showed that the color changes after 28 days of exposure to the solutions were clinically unacceptable (ΔE*>3.3) for all experimental groups. This agrees with the study by ALDREES et al. (2015). However, the brands and solutions at this time did not show significant differences.

No studies were found on the action of Amazon substances studied in the present study on orthodontic elastics, however, a study conducted by LEITE et al. (2014) evaluated the action of acai juice on composite resins and found that the color change may be different and more significant in certain materials after two and a half months of immersion. Thus, in the present study, there might have been a greater color change with a longer study time, however, the chain elastics are changed every 28 days (orthodontic maintenance) and, therefore, no studies were conducted with a longer time, which could have led to color changes different from the other fruits.

The findings on the pigmentation of Tucumã may be related to the significant number of carotenoids present in this yellow/orange colored fruit, added to its oily characteristic (NORONHA et al., 2019) that may entail a greater impregnation of the pigment to the surface of the rubber band and thus promote clinically unacceptable color changes, such as those presented.

Thus, the null hypothesis of this study, that there would be no greater staining and strength degradation when the substances from the Amazonian diet were used, was not rejected, as all the substances tested promoted similar changes in the variables studied.

Other factors such as the configuration, amount and speed of activation, changes in the environment in which the elastics are used, such as substances present in saliva and the presence of microorganisms that were not observed in this study, should be evaluated, as they may influence the color and force degradation of the chain elastics.

However, this research is important for the guidance of patients who may consume such substances, as well as to guide orthodontists as to the best elastic to be used depending on the clinical case and, therefore, the need for greater or lesser force. This study also demonstrates the importance of developing innovations in orthodontic materials to eliminate these problems.

5 CONCLUSION

We conclude that for all brands, there is a greater degradation of forces in the first 24 hours, with elastic recovery after this period; all solutions promote degradation of forces in the evaluated elastics and, for all brands tested, the color change is clinically unacceptable after 28 days of immersion.

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