The Effect of Immersion Time in Three Kinds of Carbonated Beverages on Orthodontic Elastic Latex’s Tensile Strength (In Vitro)

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Abstract

Objective: To study the effects of immersion time in three kinds of carbonated beverages on orthodontic elastic latex’s tensile strength

Methods: Subjects consist of 32 specimens orthodontic elastic latex ¼” and 4.5 oz of power, divided into 8 groups (IA, IB, IC, ID, IIA, IIB, IIC, and IID). Each group are immersed in artificial saliva (pH7) and stored in incubator (37 °C) for 24hrs for group I and 48hrs for group II. Each treatment groups will be immersed in three different carbonated beverages for 90s per day. Elastics being measured its tensile strength for group I at 24th hour, and 48th hour for group II using tension gauge. The data was tested with two way anova and post hoc Tukey.

Results: The result shows immersion time decreases elastic latex’s tensile strength (p < 0.05), and carbonated beverages affect elastic latex’s tensile strength (p < 0.05).

Conclusion: (1) There is a difference of orthodontic elastic latex tensile strength in the immersion in carbonated beverages for 24 and 48 hours, (2) there is a difference of elastic latex tensile strength orthodontic in the immersion in three kinds of carbonated beverages, and (3) there is interaction between immersion time in carbonated beverages and carbonated beverage brands

Keywords: carbonated beverage, orthodontic elastic latex, tensile strength

Introduction

Total consumption of carbonated beverages increased in the last decade. It has been reported that total production of soft drinks reaches 10 billion per year.1 Survey from National Soft Drink Association shows that consumption rate of soft drink in U.S. in 2002 is about 53 gallons per year, or equal to 16 oz. per day.2 Among 427 high school students from Jakarta, Indonesia, 389 students said that they had consumed carbonated beverages with Coca cola as the most favorite brand.3 The important reason that made people consume more various beverages is the increases of people welfare.4

Carbomated beverage contains low pH, sugar, and additive which can cause dissolution dental enamel and/or tooth erosion,5 and make acid condition to oral cavity.6 Acidifier agent and carbon dioxide that dissolved in carbonated beverage will react and produce carbonic acid so the pH level will be fall at 3.2-3.7.6,10

Cola is the most favorite flavor among carbonated beverages,11 survey that has been held by author in Laboratorium Riset Terpadu Faculty of Dentistry Universitas Gadjah Mada among some cola flavored beverage shows that Coca cola pH level is 3.25, Pepsi cola 2.79, and Big Cola as Indonesian new carbonated brand is 2.93.

Elastic latex as an active component part of fixed orthodontic must be replaced regularly so it can produce the right power amount needed of tensile strength.12 Elastic latex available on many power and size which can be chosen based on its uses, for example diagonal elastic can be used for correction of midline deviation, while extraoral elastic can be used for extraoral anchorage.13 Elastic latex made from natural rubber latex (Hevea brasiliensis) with chemical structure of natural rubber is cis-1,4 polisoprene.14 Rubber particle bonds each other through head to tail chain and has cross-linking structure with sulphur after vulcanization process.15 Longer polyisoprene chains produce bigger rubber power, although it can be broken into shorter
polysisoprene chains caused by oxidation reaction and lead to strength degradation.\textsuperscript{16}

Active stabilization ability of periodontal ligament determines the amount of orthodontic force limit, force that smaller than stabilization level of periodontal ligament causing ineffective treatment, while the bigger one can cause undermining resorption.\textsuperscript{17} About 25\% force degradation happened in 24 hours’ retraction.\textsuperscript{18} Many conditions of oral cavity induce force degradation of orthodontic elastic latex.\textsuperscript{19} Wet condition of oral cavity lead to decreases of 10\%-40\% initial tensile strength.\textsuperscript{20,22} Daily consumption of beverage can also lead to force degradation of elastic latex.\textsuperscript{23} It has been concluded by many researchers that replacement of elastic latex should be done every day, but the other researchers suggested elastic latex replacement should be done every three days.\textsuperscript{21,24} The observation about force degradation is focused before 72 hours’ retraction of elastic latex, because it will be broken after 72 hours’ retraction in wet condition.\textsuperscript{25}

Force degradation of elastic latex tensile strength is caused by the acid condition of oral cavity,\textsuperscript{9-10,26} and acidity of daily foods and beverages.\textsuperscript{23} Some researchers concluded that there is no correlation between pH and force degradation,\textsuperscript{22} and acid condition not induced force degradation on latex elastic.\textsuperscript{27,30}

**Methods**

Eight acrylic blocks (Figure 1) 37.25 mm x 50 mm x 10 mm in size planted with 4 pairs of pin made by stainless steel wire 0.9 mm in diameter with 19.05 mm in distance between pairs. Thirty-two specimens of orthodontics elastic latex (American Orthodontics \(\frac{1}{2}”\) 4,5 oz.) were divided into 8 treatment groups, 4 samples in each group.

![Figure 1. Acrylic block pinned with 0.9 mm stainless steel and 19.05 mm in distance between](image)

Carbonated beverages used are Coca Cola (PT. Coca Cola Bottling Indonesia), Pepsi Cola (PT. Prima Cahaya Indobeverage), and Big Cola (PT. Ajeindonesia Cikarang).

Artificial saliva produced by Analytical Chemistry Laboratory, Faculty of Science, Universitas Gadjah Mada, with pH 7 (Dipotassium Hydrogen Phospat (K2HPO4) 0.2g/L; Calcium Phospat (Ca3(PO4)2) 0.3g/L; Potassium Tiosianate (KCN) 0.33g/L; Sodium Bicarbonate (NaHCO3) 1.5g/L; Sodium Chloride (NaCl) 0.7g/L; Potassium Chloride (KCl) 1.2g/L; dan Urea ((NH2) CO) 0.13g/L).

Elastic latex retracted in acrylic block pin with 19.05 mm in distance (3 times of lumen width) and immersed in the artificial saliva (IA, IIA), carbonated beverages for 90 seconds per day before immersed in artificial saliva (IB, IC, ID, IIB, IIC, and IID). Immersion in carbonated beverages using Coca Cola (IB, IIB), Pepsi Cola (IC, IIC), and Big Cola (ID, IID). Immersion time group I in the artificial saliva is 24 hours, while group II immersed for 48 hours. After 24 hours’ immersion, group I measured with tension gauge, and group II measured after 48 hours’ immersion. The immersion in artificial saliva held in 37OC temperature inside the incubator (Sanyo, Japan). The measurement done by tension gauge (Dentaurum, accuracy 28.35 gr) with 31.75 mm retraction distance (5 times lumen width). The result recorded in the work table.

![Figure 2. Measurement of elastic latex tensile strength using tension gauge](image)

The effect of immersion time and kinds of carbonated beverages tested by two way anova and post hoc test tukey using Statistical Product and Service Solution (SPSS v.17) with significant level adjusted to 5\%. T test are used to compare means between each group.

**Result and Discussion**

Observation of the effect of immersion time in three kinds of carbonated beverages on orthodontic elastic latex tensile strength has been done in Laboratorium Riset Terpadu, Faculty of Dentistry, Universitas Gadjah Mada. The measurement by tension gauge has resulted elastic latex tensile strength on grams. Means and standard deviation of measurement result shown in Table 1.
The result of t test between each group (Table 4) shows that the lowest tensile strength is produced by group IIB (artificial saliva) which had differences with all of treatment groups. There is a difference between groups IB-IIB, IC-IID, and ID-IID.

Mean of elastic latex tensile strength in this research show that much longer immersion time in every kind of immersing media will make bigger force degradation. It can be happened because much longer immersion time made much more water can get inside between latex molecules. Immersion in artificial saliva produce the lowest tensile strength compared with the other groups which had immersed in carbonated beverages. Acid component of carbonated beverages affects the elastic latex molecule so it prevented from force degradation.

Force degradation in every immersing media can be happened because elastic latex accepted higher force beyond its limit tension, so it leads making some weakness point in elastic latex molecule structure. This weakness point was made by inhomogeneous superficial molecule or molecule inside. Elastic latex has covalent bond structure consisted of long polyisoprene with cross-linked sulphur. Inhomogeneous structure of cross-linked sulphur on polyisoprene chain causing some space to get water absorbed inside, produce weaker structure in every wet condition. Eng and Ong (2001) explained that there is two phase of force degradation in latex elastic. The first phase is short period in 30 minutes beginning of elastic retraction, which physical relaxation happened because the changing of long polyisoprene chain that collide each other and release free energy that work on elastic so the force resultant decreased. This phase of degradation forms log curve of strength-time. Second phase of force degradation needed longer time because it happens by the chemical relaxation. This phase is slower than the one before and forms liner curve based on the condition where elastic get placed.

Long chain of polyisoprene in three dimensional may collide each other so affects the force entropy and decrease free force that work on elastic. It might happen while elastic is being stretched many times like in mastication process and in its installation. This made the measurement of elastic latex only must be done one times for every specimen because it degrades the tensile strength.

This research shows that orthodontic elastic latex immersed 90 seconds in carbonated beverages with acid pH not lead to force degradation of tensile strength (p > 0.05). The mean difference between control group and treatment control in statistical analysis resulted negative numbers, it means that control group has lower force than the treatment groups. This theory is match with Sauget et al. (2011) that there is no correlation between pH and force degradation. T test result between each group shows that there is a difference between 48 hours’ artificial saliva group and all of treatment groups, so it can be concluded that carbonated beverages gives manipulation to prevent force degradation of elastic

### Table 1. Measurement result of orthodontic elastic latex tensile strength immersed for 24 hours and 48 hours in 3 kinds of carbonated beverages and artificial saliva pH 7

<table>
<thead>
<tr>
<th>Variable</th>
<th>Artificial Saliva</th>
<th>Coca Cola</th>
<th>Pepsi Cola</th>
<th>Big Cola</th>
</tr>
</thead>
<tbody>
<tr>
<td>24 hours</td>
<td>74,419 ± 4,092</td>
<td>79,735 ± 3,544</td>
<td>79,734 ± 3,544</td>
<td>79,734 ± 3,544</td>
</tr>
<tr>
<td>48 hours</td>
<td>38,981 ± 4,092</td>
<td>63,788 ± 6,786</td>
<td>60,244 ± 4,979</td>
<td>60,244 ± 4,979</td>
</tr>
<tr>
<td>7,088</td>
<td>8,184</td>
<td>12,276</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Normality test has done by Shapiro-Wilk. Probability score for artificial saliva group is 0.79. Coca Cola group 0.156, Pepsi Cola group 0.202, and Big Cola group 0.175. Every group shows probability score >0.05. It was concluded that the data distribution is normal.

The result of Levene’s test of homogeneity was shown probability score 0.16 (p>0.05), but there is significant difference between one carbonated brand to the others (p<0.05) (Table 2). This theory is match with Eng and Ong (2001) who explained that there is two phase of force degradation in latex elastic. The first phase is short period in 30 minutes beginning of elastic retraction, which physical relaxation happened because the changing of long polyisoprene chain that collide each other and release free energy that work on elastic so the force resultant decreased. This phase of degradation forms log curve of strength-time. Second phase of force degradation needed longer time because it happens by the chemical relaxation. This phase is slower than the one before and forms liner curve based on the condition where elastic get placed.

Long chain of polyisoprene in three dimensional may collide each other so affects the force entropy and decrease free force that work on elastic. It might happen while elastic is being stretched many times like in mastication process and in its installation. This made the measurement of elastic latex only must be done one times for every specimen because it degrades the tensile strength.

### Table 2. The result of two way anova effect of time, brand, time*brand on orthodontic elastic latex tensile strength.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sum of square</th>
<th>Df</th>
<th>Mean square</th>
<th>F</th>
<th>Sig. (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>time</td>
<td>3178.815</td>
<td>1</td>
<td>3178.815</td>
<td>62.629</td>
<td>0.000*</td>
</tr>
<tr>
<td>brand</td>
<td>1273.091</td>
<td>3</td>
<td>424.364</td>
<td>8.361</td>
<td>0.001*</td>
</tr>
<tr>
<td>time*brand</td>
<td>758.218</td>
<td>3</td>
<td>252.739</td>
<td>4.979</td>
<td>0.008*</td>
</tr>
<tr>
<td>Total</td>
<td>152456.913</td>
<td>19</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

*significance level p < 0.05

Post hoc Tukey test shows there is no correlation between one carbonated brand to the others (p > 0.05), but there is significant difference between elastic latex without having contact with carbonated beverages and the others which been immersed in carbonated beverages for many seconds (p < 0.05) (Table 3).

### Table 3. Post hoc Tukey test result among brands related with elastic latex tensile strength

<table>
<thead>
<tr>
<th>Tensile strength</th>
<th>Mean difference</th>
<th>Sig. (p)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Artificial saliva</td>
<td>Coca cola</td>
<td>-15,061</td>
</tr>
<tr>
<td></td>
<td>Pepsi cola</td>
<td>-15,060</td>
</tr>
<tr>
<td></td>
<td>Big Cola</td>
<td>-13,289</td>
</tr>
<tr>
<td>Coca Cola</td>
<td>Pepsi cola</td>
<td>0.000</td>
</tr>
<tr>
<td></td>
<td>Big Cola</td>
<td>1,771</td>
</tr>
<tr>
<td>Pepsi Cola</td>
<td>Big Cola</td>
<td>1,771</td>
</tr>
</tbody>
</table>

*significance level p < 0.05
latex. Protein contained in elastic latex has ampholytes characteristic or usually called zwitter ion, which can be cation in acid condition and can be anion in base condition.\textsuperscript{28}

Table 4. Result of t test on each means of elastic latex tensile strength immersed in 24 hours and 48 hours in artificial saliva, Coca cola, Pepsi Cola, and Big Cola

<table>
<thead>
<tr>
<th></th>
<th>IA</th>
<th>IB</th>
<th>IC</th>
<th>ID</th>
<th>IIA</th>
<th>IIB</th>
<th>IIC</th>
<th>IID</th>
</tr>
</thead>
<tbody>
<tr>
<td>IA</td>
<td>0</td>
<td>.638</td>
<td>.319</td>
<td>.058</td>
<td>.006*</td>
<td>.092</td>
<td>.182</td>
<td>.161</td>
</tr>
<tr>
<td>IB</td>
<td>.638</td>
<td>0</td>
<td>.638</td>
<td>.495</td>
<td>.012*</td>
<td>.015*</td>
<td>.133</td>
<td>.170</td>
</tr>
<tr>
<td>IC</td>
<td>.319</td>
<td>.638</td>
<td>0</td>
<td>1.000</td>
<td>.000*</td>
<td>.102</td>
<td>.037</td>
<td>.022*</td>
</tr>
<tr>
<td>ID</td>
<td>.058</td>
<td>.495</td>
<td>1.000</td>
<td>0</td>
<td>.001*</td>
<td>.035</td>
<td>.058</td>
<td>.049*</td>
</tr>
<tr>
<td>IIA</td>
<td>.006*</td>
<td>.012*</td>
<td>.000*</td>
<td>.001*</td>
<td>0</td>
<td>.011*</td>
<td>.006*</td>
<td>.005*</td>
</tr>
<tr>
<td>IIB</td>
<td>.092</td>
<td>.015*</td>
<td>.102</td>
<td>.035</td>
<td>.011*</td>
<td>0</td>
<td>.495</td>
<td>.391</td>
</tr>
<tr>
<td>IIC</td>
<td>.182</td>
<td>.133</td>
<td>.037</td>
<td>.058</td>
<td>.006*</td>
<td>.495</td>
<td>0</td>
<td>.495</td>
</tr>
<tr>
<td>IID</td>
<td>.161</td>
<td>.170</td>
<td>.022*</td>
<td>.049*</td>
<td>.005*</td>
<td>.391</td>
<td>.495</td>
<td>0</td>
</tr>
</tbody>
</table>

*significance level $p < 0.05$

Elastic protein both in acid or base condition, will attract free radical of H\textsuperscript{+} and OH\textsuperscript{-} which will attack double bonded polisoprene chain and broke the structure molecule of elastic latex.\textsuperscript{27} The main weakness of elastic latex affected by basic characteristic of natural rubber latex, which is intolerant from ozon, free radicals, and organic solvent with a lot of free OH\textsuperscript{-} contained.\textsuperscript{16}

Isoelectric point of latex protein lies between pH 3.9-4.6.\textsuperscript{29} On its isoelectric point, protein cannot perform electrical migration, so the protein become less reactive ionically.\textsuperscript{28} Acidity level of carbonated beverages is around isoelectric point, so the latex protein cannot actively react and become more stable because its neutral electronegativity.\textsuperscript{27} It explains that in the acid condition, become more stable because its zero charge of electronegativity. This theory can be proven by observing the micro structure using electron microscope. Acid protein latex will react with PO4 forms weak acid which is difficult to ionize in water solvent. In the base condition, interaction between Ca and OH\textsuperscript{-} from strong base got easier to ionize in water. It makes force degradation in base condition is bigger than the acid condition.\textsuperscript{30} This theory is match to some researchers\textsuperscript{22,27,30} that shows the tensile strength in acid condition is bigger than any other.

Protein denaturation can happen because addition of acid mineral or base mineral. Addition of ion H\textsuperscript{+} in acid condition can change –COO\textsuperscript{-} group into COOH. so, the attractive force between –COO\textsuperscript{-} group and NH3\textsuperscript{+} group will disappear, then the salt binding in protein molecule will be broken.\textsuperscript{28} In this research protein denaturation, might be not affected elastic latex tensile strength because acidity level that close to protein latex isoelectricity point, so the protein groups are neutral. Data validity in this research affected by small number of samples, the following research could be held with bigger sample amount to get better data validity.

Conclusions

The conclusion of this research is:

1. There is a difference of orthodontic elastic latex tensile strength in the immersion in carbonated beverages for 24 and 48 hours.
2. There is a difference of orthodontic elastic latex tensile strength the immersion in three kinds of carbonated beverages.
3. There is interaction between immersion time in carbonated beverages and carbonated beverage brands. Although the result shows that carbonated beverages can maintain elastic latex’s tensile strength, the use of carbonated drink should be limited due to its effects on tooth enamel. In addition, there is research need to be held further using electron microscope to see the micro molecule changing with bigger number of sample to get better data validity.
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