

## Decreasing Enamel Hardness to Solvents Packaged Lemon Juice (Citrus limon)

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### Abstract

Indonesia is a tropical country that is rich in agricultural products, one of which is fruit, but public knowledge about the effects of lemon consumption on oral health is still very low. The increase in consumption of packaged drinks is evident in the world, including Indonesia. This increase mainly occurred in the younger age group. Riskesdas data (2013) shows the prevalence of the Indonesian population with dental and oral problems as much as 25.9% and according to World Wide Food (2014) Indonesia ranks in the top five in consuming soft drinks.

Explain the decrease in surface hardness of tooth enamel against immersion in a packaged lemon juice solution.

Laboratory Experimental Research (in vitro) with pretest and posttest research designs with group control design. After that, hardness measurements were made using Vickers Micro Hardness.

There was a significant difference from the average surface hardness of the enamel before being soaked in packaged lemon solution and after being soaked in packaged lemon solution ( $p < 0.05$ ).

Based on the results of this study, packaged lemon juice solution can reduce the surface hardness of tooth enamel.

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### Introduction

Dental and oral health is one of the most important things for the health of every society. In this modern era, people's lifestyles are increasingly diverse. Tooth substance loss associated with erosion by acidic foods and soft drinks is an increasing social problem because it is frequently linked with individual's lifestyle and eating habits. According to experts, the acid content in the food and drinks eaten can damage tooth enamel and cause corrosion of teeth.<sup>1</sup>

Indonesia is a tropical country that is rich in agricultural products, one of which is fruit. Fruits are very popular with many people and consumed by almost everyone because they are refreshing and have many benefits, but public knowledge about the effects of lemon

consumption on oral health is still very low. The increase in consumption of packaged drinks is evident in the world, including Indonesia. This increase mainly occurred in the younger age group.

Riskesdas data (2013) shows the prevalence of the Indonesian population with dental and oral problems as much as 25.9% and according to World Wide Food (2014) Indonesia ranks in the top five in consuming soft drinks.<sup>2</sup> Production of packaged fruit juice at this time has increased by 30%. The development of lemons in Indonesia according to data from the Ministry of Agriculture, lemon production reached 30 tons per month in 2016 on the island of Java.<sup>3</sup>

Citrus limon (L.) Burm. f. is a tree with evergreen leaves and yellow edible fruits from the family Rutaceae. In some languages, C. limon is known as lemon (English), Zitrone (German), le citron (French), limón (Spanish), and níngméng, 檸檬 (Chinese). The genus Citrus includes evergreen plants, shrubs or trees (from 3 to 15 m tall). Their leaves are leathery, ovoid or elliptical in shape. Some of them have spikes. The flowers grow individually in leaf axils. Each

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flower has five petals, white or reddish. Lemon (*Citrus limon*) is a plant that has properties as natural antioxidants because it contains vitamin C, phenolic acids, coumarins, carboxylic acids, aminoacids, flavonoids, essential oils.<sup>4,5</sup>

Tooth enamel the most highly mineralized tissue in the body, the outermost and most hard layer of the tooth, serves as a protective layer for underlying dentin and pulp. By weight, it is made up of 96% inorganic material, 4% organic material, and a small amount of water. Hydroxyapatite nanocrystal enhances mechanical and physical properties of enamel, including its acid resistance.<sup>6</sup> Enamel may undergo remineralization and demineralization processes. Remineralization is repair process of tooth mineral, while demineralization is process of mineral loss from the tooth surface. The ratio between the process of remineralization and demineralization can determine the hardness and strength of the teeth.<sup>7</sup>

Minerals contained in this tooth structure stability is influenced by the condition of the mouth area, especially the pH of the mouth. It is known that consumption of soft drinks results in an apparent fall in salivary pH. This occurs depending on the intrinsic pH value and buffering capacity of the drinks.<sup>8</sup> Enamel demineralization could occur when the enamel is in an acidic environment (pH below 5.5).<sup>9</sup> However, other important factors including duration, frequency, exposure time and beverage temperature of the drink determines the enamel dissolution abilities of these drinks.<sup>10</sup> Moreover, an organic acid produced by fermentation of sugar contents of the drinks by the microorganisms present in the plaque further lead to demineralization and caries.<sup>11</sup> The process of tooth demineralization begins with the release of calcium from tooth enamel. If this demineralization continues, it will cause the erosion of some of the enamel minerals, and if the infection has reached the dentin, you will feel pain.<sup>12</sup>

Then the decrease in pH degrees can cause a progressive interaction between acid ions and hydroxyapatite phosphate. This situation will affect the solubility energy of all crystallites on the enamel surface. The stored fluoride is released in this process, which will react with  $\text{Ca}^{2+}$  and  $\text{HPO}_2/4$ , resulting in remineralization.<sup>13</sup> Currently, there are still many people who do not know about how the effects of the elements in lemon can have an impact on

dental and oral health. For this reason, scientific tests need to be carried out to find out how the effect of the acid from lemon on the hardness of tooth enamel. Based on this, the authors are interested in examining the decrease in lemon

## Materials and methods

The type of research that will be used is Laboratory Experimental Research (in vitro) with a pre-test and post-test research design with a control group design. This research was conducted at the Technical Laboratory of Tarumanegara University. This lab will be the research choice because this lab has a tool to measure the hardness of the tooth surface, namely the Vickers Micro Hardness Tester Machine. The time of the study was carried out in April - June 2022. The population in this study was the maxillary second premolars. The sample in this study were 32 maxillary second premolars that met the inclusion criteria. The inclusion criteria in this study were intact crowns, no caries, no fillings. While the exclusion criteria in this study were teeth with caries, fractured teeth.

After getting the results of the measurement of the surface hardness of the tooth enamel, a normality test was carried out by performing the Saphiro Wilk test, then if the data were normal, the Paired T-Test test was carried out, this test was to obtain results before and after soaking lemon and aquadest. Furthermore, for the test between groups after soaking lemon and aquadest, the Independent T-Test test was carried out, if the results were not normal, the Wilcoxon test was carried out.

## Results

This study was conducted to determine the difference in the surface hardness of the enamel before and after soaking in a solution of packaged lemon and aquadest. This study was conducted from 11 April to 17 June 2022 using 32 samples of maxillary second premolars that matched the inclusion and exclusion criteria.

Table 1 shows the research data from observations for 5, 10, 15 and 20 minutes at 7 days and the value of the surface hardness of tooth enamel before and after immersion in a solution of packaged lemon and aquadest using the Vickers micro hardness tester machine in VHN units.

Larutan Lemon		Durasi Perendaman	Aquadest	
Pretest	Posttest		Pretest	Posttest
382.3	368.3	5 Menit	372.5	369.3
359.3	345.5		345.3	344.6
362.7	348.3		355.3	354.8
372.8	358.5		364.2	363.6
360.3	331.2	10 Menit	348.9	346.8
358.2	329.4		362.9	360.7
338.6	309.8		340.5	339.4
361.2	332.3		340.6	339.1
339.9	286.2	15 Menit	351.9	349.8
356.8	300.8		330.8	329.1
341.2	287.4		361.2	359.6
320.3	265.4		318.6	317.2
320.8	235.8	20 Menit	325.2	324.6
328.6	247.3		361.2	358.3
336.2	255.3		340.8	337.6
329.6	251.6		318.9	315.9

**Table 1.** Research Result Data.

Based on table 2 of the results of the paired T-test, it was obtained a significant value of 0.200 where  $p > 0.05$  that there was no significant difference from the average enamel surface hardness before immersion and after immersion with distilled water, so it can be concluded that there is no significant difference between before and after immersion in distilled water on the hardness of tooth enamel.

Kelompok Data	N	Rerata ± SD	Sig. (2 tailed)
Sebelum perendaman aquadest – Sesudah perendaman aquadest	16	1.70 ± 1.08	0.200

**Table 2.** Results of the Paired T-Test Aquadest

Based on table 3 of the results of the paired T-test, it was obtained a significant value of 0.000 where  $p < 0.05$  that there was a significant difference from the average surface hardness of the enamel before being soaked in packaged lemon solution and after being soaked in packaged lemon solution, so it can be concluded that there was a significant difference between before and after being soaked by packaged lemon solution on the hardness of tooth enamel.

Kelompok Data	N	Rerata ± SD	Sig. (2 tailed)
Sebelum perendaman larutan lemon kemasan – Sesudah perendaman larutan lemon kemasan	16	44.73 ± 26.47	0.000

**Table 3.** Results of Paired T-Test of Packaged Lemon Solution.

Based on Table 4 from the results of the Independent T-test, it was obtained a significant value of 0.002 where  $p < 0.05$  that there was a significant difference in the average enamel surface hardness between the immersion of packaged lemon solution and distilled water with the average hardness of tooth enamel. The packaged lemon solution tends to be lower than the aquadest so it can be concluded that the packaged lemon solution has a significant effect on reducing the surface hardness of tooth enamel.

Kelompok Data	Sig. (2 tailed)
Independent T-Test	0.002

**Table 4.** Results of Independent T-Test.

### Discussion

Soft drinks that can erode the surface of the enamel are drinks that contain carbohydrates that are easily fermented and very acidic so that these drinks are not easily removed by saliva. There are several factors that affect the demineralization process, namely the type and concentration of acid, carbohydrate content, and the degree of acidity (pH). There has also been increased interest in the dental effects of soft drink beverages due to the escalating (an increase of 56%, rising approximately 2-3% per year) consumption by children and adolescents over the last decade.<sup>14</sup> This study aims to determine the effect of packaged lemon solution and aquadest as a control treatment with a concentration of 100% on tooth enamel demineralization by looking at changes in the value of tooth enamel hardness. In this study, the hardness test was carried out twice, namely before being treated with packaged lemon solution and aquadest and after being treated.

To test the surface hardness of tooth enamel using the Vickers Micro Hardness Tester Machine because this tool is used to see the hardness in tooth enamel. The duration of immersion of tooth enamel in this study was 5 minutes, 10 minutes, 15 minutes and 20 minutes. This is based on the Fraunhofer JA study, the process of exposure between tooth enamel and a solution occurs for 20 seconds before mixing with saliva, if it is calculated in a year as much as 90,000 seconds or 25 hours per year, so the interpretation of time in this study can describe

the consumption of drinks in a year.<sup>15</sup>

Simy Mathew et al research, explained that the effect of carbonated drinks depends on the pH and acidity of the drink to determine the extent of the potential tooth damage possible. Lemon juice caused significant reduction of the tooth structure at irregular levels and increased drastically as the incubation time varied. In the present study the loss of structure for teeth immersed in fresh lemon juice was seen to increase significantly from 1 week to a period of 30 days.<sup>16</sup> Performed on 32 dental samples. The initial enamel hardness measurement was carried out before treatment. The measurement results show the average value for the entire sample, which is 339.568 VHN. The results of the study were included in the normal hardness category of tooth enamel, which ranged from 250 to 360 VHN. This result is also not much different from the study of Shishir Shetty et al, which showed that the average hardness of tooth enamel was 229.06-335.64 VHN.<sup>17</sup> The samples were then treated using a packaged lemon solution and control using aquadest, then measured the pH of the packaged lemon solution and aquadest using a digital pH meter. After being treated, the 32 samples were recalculated the surface hardness of the enamel.

The measurement results show the average value of tooth enamel hardness after being given a packaged lemon solution of 328.4 VHN. Enamel damage also does not depend only on pH but the buffer capacity of the drink because each beverage solution has a different concentration and buffer capacity so that it has a different erosive effect when in contact with the tooth enamel surface. The higher the buffer capacity, the greater the erosion that occurs on the tooth surface because the buffer increases the demineralization process. Tooth erosion begins with the release of calcium ions and if this continues it will cause partial loss of the enamel prism, if it continues it will cause porosity. Porosity causes the surface hardness of tooth enamel to decrease.

A large decrease in the surface hardness of tooth enamel due to immersion in an acidic drink is in accordance with previous research, which states that if there is a decrease in one unit of pH, it will cause the rate of calcium release by 19.5 times, the lower the pH or the more acidic, the higher the rate of calcium release. reaction to the release of calcium from tooth enamel. Based

on the results of the independent t-test, it showed that the average enamel surface hardness between the immersion of packaged lemon solution and distilled water with the average tooth enamel hardness resulted in a significant change ( $p < 0.05$ ).

## Conclusions

Based on the results of research on differences in the hardness of tooth enamel soaked with packaged lemon solution and distilled water in vitro, there are several conclusions, namely:

1. There was a decrease in the hardness of tooth enamel after soaking with a packaged lemon solution.
2. There was a decrease in the hardness of tooth enamel after soaking with distilled water.
3. There were significant changes before and after soaking with packaged lemon solution.
4. There was no significant change to the change in the surface hardness of the tooth enamel in aquadest immersion.
5. There is a significant difference in changes in the surface hardness of tooth enamel between packaged lemon solution and aquadest.

## Declaration of Interest

The authors report no conflict of interest.

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