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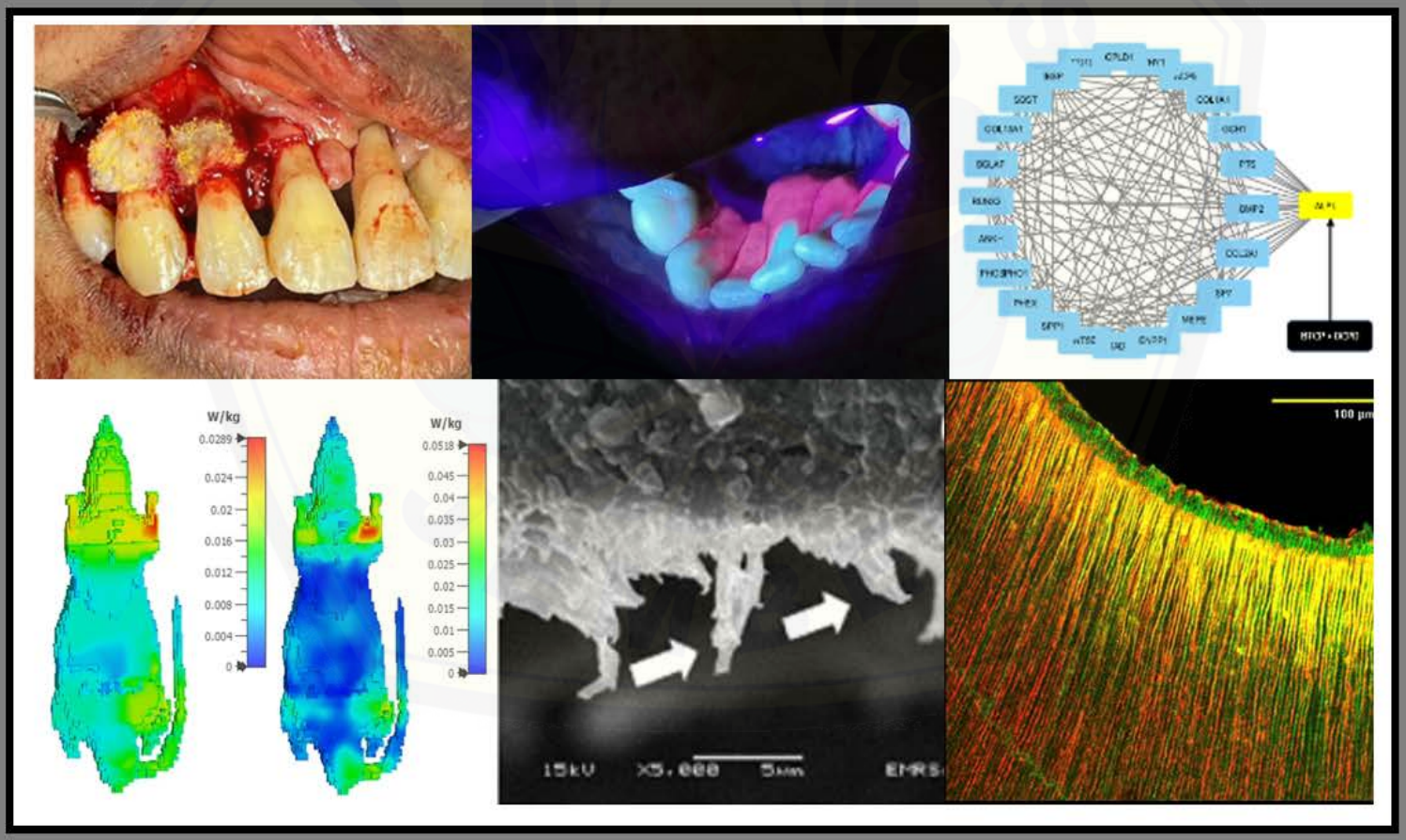

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Comparison of Release of Nickel and Nickel Chromium Ions on Restoration after Soaking Steeping Robusta and Arabica Coffee

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Abstract

Robusta and Arabica coffee are two types of coffee widely consumed by Indonesians. Both tend to be acidic in pH level when they are brewed. Patients who experience prosthodontic treatment using NiCr metal restorations and consume coffee habitually will be more liable to salivary pH decrease, thus accelerating the corrosion process on the restorations and causing the release of metal ions.

This study aims to determine the comparison of Ni ion release in NiCr restoration after being immersed in Robusta and in Arabica coffee brew. Furthermore, this study also intends to find out how the length of immersion will affect on the amount of released Ni ions. The design of this study is post test control group design.

27 NiCr restoration samples in circular shape (d = 10mm, t = 1mm) were divided into 9 groups, and each were incubated at 37°C. Afterwards, a test on Ni ion release was conducted by using the Atomic Absorption Spectrometry tool. Statistical analysis used the data is analyzed by the one way ANOVA test which yielded data significance value p=0.000 (p<0.05).

The release of Ni ions in NiCr restorations after immersion in Arabica is greater than that in Robusta coffee. Moreover, the length of immersion process also has an effect on the number of Ni ions being released.

Experimental article (J Int Dent Med Res 2024; 17(2): 507-511)

Keywords: Arabica coffee, Nickel ion release, NiCr restoration, Robusta coffee, Soaking process.

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Introduction

Coffee (*Coffea* Sp.) is one of the most important trading commodities in the world, which is cultivated in various countries, including Indonesia. Coffee has become one of the plantation commodities in Indonesia with the largest production quantity. Thus, Indonesia is included in the four largest coffee suppliers in the world alongside Brazil, Colombia and Vietnam[1]. Based on the results of the National Socio-Economic Survey (*SUSENAS*) by *BPS*, coffee bean or ground form is generally demanded for household consumption. From 2002 to 2014, coffee consumption per capita did not experience any significant changes. It was 1,298 kg in 2002 and only increased by 3.78% to 1,347 kg in 2014[2].

Coffee is one of the most common diet drinks in the world[3,4], and there are many different types of coffee on the market but Robusta and Arabica dominate production in Indonesia[2]. Robusta and Arabica coffees are acidic drinks and are widely consumed by the local people. Both types are different in pH value when brewed. While Robusta is 5.61-5.69, Arabica coffee reaches 5.16-5.23. The pH value contained in coffee comes from the acid content contained in coffee beans, and the place where the coffee plants grow[5]. Coffee consumed can also cause pH changes in the oral cavity[6].

Prosthodontics treatment patients who have a high frequency of coffee consumption and use metal restoration will experience a pH deficiency in their saliva. Saliva containing protein ions and chlorides can affect the release of metal ions. Protein acts as an electrolyte medium that can trigger chemical reactions, while chloride has a metal destruction mechanism when it comes into

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contact with a layer of chromium oxide which is a protective layer from corrosion in NiCr alloys[7,8].

One of the commonly used metal restoration materials for crowns in the prosthodontic field is NiCr. This condition will accelerate corrosion in the restorations, because a higher concentration of acid in the oral cavity will also cause H^+ from the acid to increase and experience a reduction reaction. As a result, the metal ion will experience an oxidation reaction, which causes ion release in the metal[9].

The release of Ni ions in NiCr restorations can have several impacts on both the user and the NiCr restoration, such as local toxicity around restoration, inflammation, and cell death of gingival fibroblasts[10,11,12]. Ni ions as corrosion product from NiCr restoration can affect the activity of gingival fibroblast cells through the expression analysis of Bcl-2, which is a cell apoptosis regulator. The longer the cell is exposed to Ni ions, the lower the number of Bcl-2 cells[11].The release of metal ions can also cause changes in the quality of metals including changes in metal microstructure and reduction in metal strength[13].

Prosthodontics used in the oral cavity, especially those made of metal, are more vulnerable to corrosion. The contact duration of metal restorations with saliva affects the release of metal ions. The previous studies[14] found that the large number of metal ions released from NiCr restorations is proportionate to the length of time when the metal interacts with its environment. The Ni ion release in the NiCr restoration started to happen on the first day after contact with saliva of pH 6.7 and continued to increase on the 3rd and 7th day. In this study, the soaking process was done as long as that in the preliminary studies, i.e. 1, 3 and 7 days. The process is meant to see whether the Ni ion release pattern is the same as the previous researches.

Based on the description above, the authors intends to analyze the difference in the release of Ni ions between NiCr restoration immersed in Robusta coffee brew and that in Arabica coffee brew with various immersion times.

Materials and methods

This study is a laboratory-experimental research and uses the post-test-only control group design. It was conducted from November to December 2017 in several places: Microbiology Laboratory at the Faculty of Dentistry of Jember University for the manufacture of test solutions; Bioscience Laboratory at the same university for the treatment; Kurnia Dental Laboratory Surabaya for sample making; and the Surabaya Center for Health Laboratory for Ni ion release testing.

There were 27 samples divided into 9 groups: control (immersion in saliva baffle), group A (immersion in artificial saliva + Robusta coffee brew), group B (immersion in artificial saliva + Arabica coffee brew). Each was split into 3 smaller groups according to the length of the immersion time: control group 1 soaked for 1 day, control group 2 soaked for 3 days, control group 3 soaked for 7 days, group A1 soaked for 1 day, group A2 soaked for 3 days, group A3 soaked for 7 days, group B1 soaked for 1 day, group B2 soaked for 3 days, and group B3 soaked for 7 days. Each sample group was placed in a shaking incubator at 37°C. Afterwards, testing was conducted to determine the number of Ni ions released using the Atomic Absorption Spectrophotometry (AAS) tool.

The results of the Ni ion release test were then analyzed by normality test using the Shapiro Wilk test and homogeneity test with Levene Test. Furthermore, the One Way Anova parametric test was carried out and continued with the Least Significance Difference test to determine the differences between one group and the others.

Results

The results of the study for control group 1, control group 2, control group 3, group A1, group A2, group A3, group B1, group B2, and group B3 can be seen in the following figure:

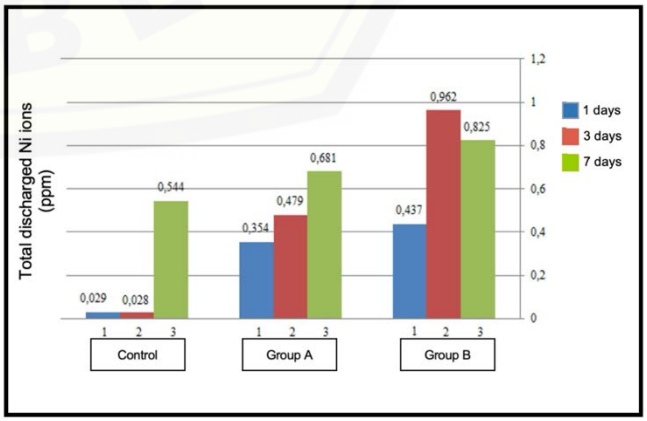

Figure 1. Histogram of the average number of Ni ions released in the immersion solution (ppm).

The research data obtained from each group was then analyzed statistically. The data were also tested for normality by the Shapiro Wilk test. The results of the normality tests that have been carried out showed that all treatment groups were normally distributed ($p>0.05$). Afterwards, the homogeneity test was conducted by using Levene test. It obtained a significance value of $p=0.107$ ($p>0.05$) which indicates that the data is homogeneous. Then the analysis was continued by using the One Way ANOVA test which yielded data significance value $p=0.000$ ($p<0.05$). This shows that there are differences in the entire study group. Afterwards, the analysis proceeded to LSD test to determine the difference between each study group. The test resulted in the value of ($p<0.05$); this showed that there were significant differences between all study groups. However, there were also several group data showing that they did not have significant differences with other groups, and they are:

a. Control group 1 (soaked in artificial saliva for 1 day) and control group 2 (soaked in artificial saliva for 3 days).

b. Group A2 (soaked in artificial saliva + Robusta coffee brew for 3 days) and control group 3 (soaked in artificial saliva for 7 days).

Discussion

The difference of Ni ion release between control groups (immersed in artificial saliva), group A (immersed in artificial saliva + Robusta coffee brew) and group B (soaked in artificial saliva + Arabica coffee brew) is caused by several factors, mostly related to pH value in immersion solution. The pH of the solution in group B was lower than that in group A and the control group. The difference in pH was caused by differences in the acid content in the immersion solution from the coffee brew. Soaking solution in the control group contained no coffee, while that in group A contained Robusta coffee with 6.1 in pH scale, and Arabica coffee brew with 5.6.

The release of Ni ions in control group, or group soaked in artificial saliva of 7 in pH level, is caused by the influence of salivary contents. Saliva consists of various electrolytes, including sodium, potassium, calcium, magnesium, bicarbonate, and phosphate. Besides, the electrolyte content of saliva also contains immunoglobulin, proteins, enzymes, mucin and some nitrogen compounds, such as urea and ammonia. The functions of this component are: bicarbonate, phosphate and urea function to modulate pH and salivary buffer capacity[13]. In this study, the saliva used is artificial saliva which contains potassium, calcium, bicarbonate, and chloride components. They are electrolytes which can trigger the occurrence of electrochemical reactions. Electrochemical reaction is a reaction that occurs at the anode and cathode. It will oxidize (release electrons) at the anode and undergo a reduction reaction (accept electrons) at the cathode. At that point, the metal ions act as the anodes, while H^+ ions from the electrolyte media become the cathode. That will lead to an electrochemical reaction that causes the release of ions in the metal[16].

Based on Figure 1, the release of Ni ions in group B (immersed in artificial saliva + Arabica coffee brew) had the most results: 0.437 ppm in group B1, 0.962 in group B2, and 0.825 in group B3. Some of the factors causing this to occur are the presence of Arabica coffee which makes the soaking solution to become more acidic or low in pH level.

The value of the chlorogenic acid in a Robusta coffee bean is 1.9 - 2.5 g/ 100g, while trigonelline (N-methylnicotinic acid) is 1.2 - 0.2 g/100g, and nicotinic acid is 0.016-0.026 g/100g in roasted coffee. Meanwhile, Arabica coffee contains 3.3-3.8 g/100g of chlorogenic acid, 0.7 - 0.3g/100g of trigonelline (N-methylnicotinic acid), and 0.014 - 0.025g/100g of nicotinic acid in roasted coffee[17]. This types of acid cause the pH level of the solution in group B to be lower than that in group A or the control group.

When saliva mixes with the coffee brew, the salivary pH will decrease and the saliva buffer function which balances the pH will not work well. As a result, the saliva buffer cannot bind H^+ properly[18]. As the concentration of acid goes higher, H^+ from the acid will also increase and a reduction reaction is more likely to occur. Consequently, the metal ion will experience an oxidation reaction which causes the release of ions in the metal[9].

Another factor causing the release of Ni ions in group B is higher than that in group A or the control group is the difference in caffeine content in both types of coffee used in soaking solutions. Caffeine in Robusta coffee is 2.4-2.5 g/100g, while Arabica coffee contains 1.1-1.3

g/100g of caffeine. Both are in the form of roasted coffee[11]. Caffeine is an alkaloid that has a purine ring and is a derivative of methyl xanthine (1,3,7,-trimethyl xanthine). The formula for the caffeine molecule is $C_8H_{10}N_4O_2$. Caffeine is a compound that contains nitrogen groups that have free electron pairs. The nitrogen groups will donate the free electron pairs to the metal, and will impede the corrosion process on the metal[19].

Based on Figure 1, the results showed that the average number of Ni ions released in group A and group B increased with the increasing immersion time. Factors that have caused the increase are: day 1 is the optimum time, when caffeine, which has the properties as a corrosion inhibitor, has the most active nature because there has not been saturation. At that point, caffeine provides the lowest corrosion current density and corrosion rate[20].

The average amount of Ni ion released in group B has also increased with the increasing immersion time. However, on the 7th day of immersion the quantity of Ni ions decreased. The factor that has caused the reduction of Ni ion release is possibly the long coffee brewing time. Long brewing time causes caffeine levels in coffee to increase. This increase in caffeine levels causes a decrease in the amount of ion release in metals, because caffeine has the property of inhibiting corrosion rates in metals[21].

Conclusions

The intensity of Ni ion release in the NiCr restoration after immersion in Arabica coffee is higher than that in Robusta coffee. There is also an increase in the number of Ni ions released from the NiCr restoration after it is soaked in Robusta coffee and Arabica coffee brew for periods of 1, 3 and 7 days.

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Declaration of Interest

The authors have no conflicts of interest to declare.

Regulatory Statement

This research was conducted in accordance with all regulations and did not use animal or human subjects.

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