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Effect of packaged coffee drinks consumption to corrosion rate of stainless steel orthodontic wire

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Abstract

Objective: To determine the effect of packaged coffee drinks consumption to corrosion rate of stainless steel orthodontic wire.

Material and Methods: This study is laboratory experimental with post-test only with control group design and using stainless steel orthodontic wire with total of 16 samples. The wire length is 6 cm and diameter is 0.41 mm. Samples were divided into 4 groups with 1 group of artificial saliva and 3 groups with a packaged coffee drinks substitution. Measurement of corrosion rate was done by using potensiostat tool and data analysis using SPSS version 23 and kruskal wallis and post hoc Mann whitney test with significant value of p>0.05.

Results: Luwak and robusta packaged coffee group had lower corrosion rate value than the control group. While arabica packaged coffee group had higher corrosion rate value than the control group.

Conclusion: Arabica packaged coffee drinks had the biggest effect on corrosion rate of stainless steel orthodontic wire.

Keywords: Corrosion, Orthodontic wire, Packaged coffee drinks, Potensiostat, Stainless steel

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Introduction

Malocclusion is a conditionthat deviates from the process of growth and development which is characterized by the disharmony of the relationship between teeth, one arch jaw with another arch, face or whole. Malocclusion causes facial appearance poor, disorders of the joint temporomandibular, speech disorders, caries risk, periodontal disease and trauma.[1]

Tools that are used to treat malocclusion can broadly be classified as removable appliance, functional appliance, and fixed appliance.[2] Treatment with fixed appliances is fixed equipment that is attached to the teeth and cannot be removed by the patient. This tool is directly attached to the teeth or installed using dental cement.[3] This fixed tool is also commonly referred to as braces and consists of several components, namely brackets, rings, archwires, and auxiliaries.[2]

Orthodontic wire is an important component of treatment orthodontic.[4] Various types of orthodontic wire on the market, including wire stainless steel, cobalt chromium, beta-titanium and nickel-titanium (NiTi). Fixed wire orthodontic that is often used is stainless steel orthodontic wire which has many advantages such as good elasticity, strength adequate, easy to form, economical, andresistant to corrosion, but the properties corrosion resistant of orthodontic wire stainless steel can be influenced by conditions in the cavity mouth.[5]

Oral cavity is an environment ideal for corrosion.[5] Corrosion is the result of the process of interaction between metal materials with the environment surrounding. One cause of the process corrosion is an environment with an acidic pH. In the process of stainless steel corrosion in theoral cavity, the release of metal ions that can enter the body and can cause effects such as carcinogenic, allergenic, mutagenic, andcytotoxic.[6]

Saliva can be influenced by stimulation of drinks that contain excessive acid. One of the drinks that contain acid is coffee.[7] However, coffee can inhibit the rate of corrosion, this is because the compound caffeine can form an iron complex (III) caffeine which will adhere to the iron surface which prevents corrosion.[8] Based on this, the researcher wants to know the effect of immersion of stainless steel wire orthodontic in packaged coffee drinks on the corrosion rate of the wire.

Material and Methods

This study is a study experimental laboratory, with apost-test with control group design. This study was conducted in September 2018 in the Biochemistry Laboratory and Integrated Chemistry Laboratory, Department of Chemistry, Faculty of Mathematics and Natural Sciences and Oral Biology Laboratory of Dentistry, Faculty of Hasanuddin University. The study design used in this study was a completely randomized design (CRD) consisting of 4 treatment groups with 4 samples per group each treatment, so that there were 16 trials.

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Table 1 **Difference in average corrosion rate of stainless steel wire (mpy) after soaking the control solution, robusta coffee packaged drink, arabica coffee packaged drink, luwak coffee packaged drink**

Treatment	N	Mean±SD	Normality test (p-value)
Control group	4	$2.04x10^{-12}$±$1.39x10^{-12}$	0.323
Robusta coffee	4	$1.01x10^{-12}$±$6.87x10^{-13}$	0.976
Arabika coffee	4	$2.66x10^{-12}$±$3.73x10^{-12}$	0.049
Luwak coffee	4	$1.27x10^{-12}$±$5.44x10^{-13}$	0.169

*Shapiro-Wilk Test : p>0.05; normal distribution data

Table 2 **Kruskal Wallis test result**

Test Statistics[a,b]	Rmpy
Chi-Square	1.147
Df	3
Asymp. Sig.	0.766

Kruskal Wallis Test
Grouping Variable: Control

The tools used in study this are in the form of beakers, glassbeakers, EDAQ potentiostats, analytical scales, stirring rods, refrigerators, cutting, pliersflat pliers. While the ingredients used are robusta coffee drinks packaged, packaged civet coffee and packaged coffee Arabica, cork, artificial saliva, orthodorm orthodorm wire of the maxillary ovoid made of stainless steel, strips ph indicator, aluminum foil.

Preparation of Artificial Saliva. Saliva is made based on the composition of saliva artificial by Fusayama KCl: 0.4 g/L, NaCl: 0.4 g/L, $CaCl_2.2H_2O$: 0.906 g/L, $NaH_2PO_4.2H_2O$: 0.690 g/L, $NaS_2.9H_2O$: 0.005 g/L, Urea: 1 g/L.

This saliva is made as much as 2 liters with 6.5 pH. Orthodontic wire preparation; The wire used in this study were 8 stainless steel wires with a diameter of 0.41 mm which were then prepared with a length 6 cm to produce 16 wire samples of the same length. After that the weight is measured wire using scales analytical.

pH Measurement; Before taking a pH measurement, mixing saliva with robusta coffee, arabica coffee, and luwak coffee is made, each with 500 ml each in a beaker, the pH strip is inserted into each beaker and then wait until a few moments, after the pH strip changes color, the color is then matched to the pH indicator to determine the pH of the solution.

Corrosion rate measurement; Preparation of the solution that has been measured pH, the laptop and the potentiostat are turned on, then connected via USB connection, saliva artificial solution products that do not have a coffee mixture placed in glas cups as much as 100 ml and then covered with cork which has been given three holes as a place of supporting electrodes, comparison electrodes and working electrodes, supporting electrodes (electrodes Pt), dipped into the glass and then connected with a red port cable, the comparison electrode (Ag/AgCl electrode) is dipped in the glass and then connected to the yellow port cable, and the working electrode (orthodontic wire which has been prepared) dipped into the glass and then connected with green port cable, echem software v.2.1.2 is opened and regulated potential range and measurement speed. In this study the potential range used is -600 mV to 600 mV with a measurement speed of 25 mV/s and a current of 100 mA and 500 µA, the measurement then starts to finish, the measurement is repeated again using artificial saliva that has been mixed with robusta coffee, arabica coffee, and luwak coffee packaged drinks, the measurement results using this software are then transferred to Microsoft Excel and then processed by making a tafel graph so that the corrosion rate of the orthodontic wire is obtained using the equation.

$$Rmpy = \frac{0.13\ Icorr\ E}{\rho}$$

R_{mpy} : Corrosion rate (mili inch/year)
Icorr : Corrosion current density (µA/cm^2)
E : Material equivalent weight (gr)
ρ : Material density (gr/cm^3)

Results

Table 1 shows the difference in the average corrosion rate of wire stainless steel (mpy) after being treated with control group measurements, group measurements with coffee robusta packaged, group measurements with the addition of arabica coffee packaged, and group measurements with the addition of luwak coffee packaged. The results based on analysis statistical showed the highest average corrosion rate wire was found in the treatment of group measurements with the addition of packaged Arabica coffee $2.66x10^{-12}$, whereas the average wire corrosion lowestrate was found in the treatment, group measurements with coffee packaged robusta $1.01x10^{-12}$. The treatment measurement of the control group is given at the average rate $2.04x10^{-12}$, while the treatment of the measurement group with the addition of luwak coffee packaged is given at the average rate $1.27x10^{-12}$.

Table 1 also shows theresults of the normality test to determine the tests statistical used in this

study. The results of Shapiro Wilk's normality test showed $p<0.05$ for all treatments except the measurement treatment group with the addition arabica coffee of normally distributed. So it does not meet the test requirements parametric where all data must be normally distributed. Therefore this study used non-parametric Kruskal Wallis test. The Kruskal Wallis test given in table 2 as follows.

From these results we can find outthe p-value or Asymp. Sig is 0.766 which means there is no difference significant between the treatment measurements of the control group, the measurement group with robusta coffee packaging, the measurement group with the addition of coffee packaged arabica, and the measurement group with the addition of luwak coffee packaged.

To find out the averageof the most influential treatments can be seen by looking at the highest average of each treatment that has the highest influence is the treatment of group measurements with the addition of arabica coffee $2.66x10^{-12}$±$3.73x10^{-12}$ followed by the treatment of control group measurements $2.04x10^{-12}$±$1.39x10^{-12}$ for treatments that have the smallest average in this case the treatmentof group measurements with coffee robusta packaged has the smallest effect compared to other $1.01x10^{-12}$±$6.87x10^{-13}$.

Discussion

The results of the study show differences in the corrosion rate of the wire after being given the measurement control measurements, measurements groups with robusta coffee packaged, measurements group with the addition of coffee arabica packaged, and measurements group with the addition of luwak coffee packaged. The results of this study indicate the highest wire corrosion rate was found in the treatment of group measurements with the addition of arabica coffee packaged $2.66x10^{-12}$. Meanwhile, the lowest wire corrosion rate was found in the treatment, measurement group with robusta coffee packaged $1.01x10^{-12}$. The measurement treatment of the group is control given at the average rate $2.04x10^{-12}$, while the treatment of the measurement group with the addition of luwak coffee packaged is given at the average rate$1.27x10^{-12}$.

From the research data that has been done the data analysis shows that there is no difference significant between the treatment of control group measurements, group measurements with robusta coffee packaging, measurements group with the addition of coffee arabica packaged, and measurements group with the addition of luwak coffee packaged.

Each packaged coffee that has been tested, has a pH of 5 which indicates that coffee is acidic. The presence of acid content that causes coffee has a low pH and is acidic, thereby reducing the pH of saliva and affecting the corrosion rate of orthodontic stainless steel wires. Concerning the release of nickel and ions chromium which were greater in drinks low pH.[5]

The results of the study in the group control treatment, the group with robusta coffee packaged, the group with the addition of arabica coffee packaged, and the group with the addition of luwak coffee packaged showed the group with the addition of arabica coffee packaged produced the highest corrosion rate. Followed by the control group, the group with the addition of luwak coffee packaged and finally the group with the addition of robusta coffee.

Conclusion

The results of research that have been done show that Arabica coffee packaged is not effective in inhibiting the rate of corrosion of orthodontic wire made of stainless steel. This is due to the average rate corrosionon orthodontic wires which were immersed with the arabica coffee packaged solution which has a higher value compared to the group control.

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Conflict of Interest

The authors report no conflict of interest.

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