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THE ANALYSIS OF WULUH STARFRUIT LEAF EXTRACT (*Averrhoa blimbi Linn*) AS INHIBITOR ON CORROSION RATE OF STAINLESS STEEL ORTHODONTIC WIRE

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ABSTRACT

Background*: One type of wire used in orthodontic treatment is stainless steel and it has a potential to corrosion due to the environment around the oral cavity. The corrosion rate may happens depends the effect from the environment around the metal. One of the method that can be done to lower the corrosion rate is by using the extract of wuluh starfruit leaf (Averrhoa bilimbi Linn) as an organic inhibitor.* ***Purpose****: The purpose of this research is to analyze the extract of wuluh starfruit leaf in lowering the corrosion rate of orthodontic stainless steel wire.* ***Methods****: This research was included as a kind of true experimental with post-test only control group design. This research consisted of control group and two treatment groups. Each group consisted of 10 sample orthodontic stainless steel wire with a length of 5 cm which was cut and scraped along the wire, then measured the corrosion rate on groups immersion in saline solution and the extract of wuluh starfruit leaf.* ***Results****: The results of this research showed that the average rate of corrosion ortodonthic stainless steel wire immersed in the wuluh starfruit leaf extract with concentration 1000 ppm was equal to 3,24x10^{-5} mm/y. The average rate of corrosion immersed in the wuluh starfruit leaf extract with concentration 600 ppm was equal to 6,31x10^{-5} mm/y and the average rate of corrosion immersed in a solution of saline was equal to 1,34x10^{-4} mm/y.* ***Conclusion****: The wuluh starfruit leaf extract can lower the corrosion rate which is indicated by the highest corrosion reduction in the group a wuluh starfruit leaf extract with concentration 1000 ppm.*

Keywords*: corrosion, organic inhibitor, stainless steel orthodontic wire, wuluh starfruit leaf extract*

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INTRODUCTION

Orthodontic treatment is used in treating dental malocclusion cases.[1] Devices in orthodontic treatment consist of fixed and removable appliances. Removable appliances are devices that can be used alone without any help from the others.[2] One of the materials contained in the removable device components is wire.[3] Orthodontic wire has various types, one of them is made from stainless steel. Stainless steel wire can be resistance to corrosion, have enough strength and also economical in price.[4]

Wire in the oral cavity potentially lead to corrosion because of environmental in the oral cavity. Things that can trigger the occurrence of corrosion processes in the oral cavity are the contact with saliva, the influence of temperature and environment.[5] Corrosion is a reaction process that occurs between the metal with the surrounding environment accompanied by detachable ions from

the elements contained in the metal. An ion released from a metal element maytrigger anallergic reaction and some other effects that may be harmful to the body.[6]

The circumstances surrounding the metal can affect the corrosion rate.[7] The corrosion rate can be interpreted as the velocity of corrosion in a material.[8] One of the things that can be done to reduce the corrosion rate is the inhibitor. A corrosion inhibitor is a solution which is present in corrosive condition, and it reduces the corrosion rate of the metal.[9] The corrosion inhibitor consists of inorganic and organic types. Organic inhibitors come from natural materials that are safer for the environment and the human body.[10]

One of the natural ingredients that can decrease the corrosion rate is the wuluh starfruit leaf (*Averrhoa bilimbi Linn*).[11] This plant belongs in the *Oxadilaceae* family from the United States in tropical climate and there were several in other countries, including Indonesia. This plant is used by Indonesian as a medicinal plant and easy to obtain. Part of this plant that has many benefits is the leaves. It contained of flavonoids, saponins, tannins, sulfur, formic acid, perokside, calcium oxalate and potassium citrate.[12] Tannins and flavonoids are compounds that can reduce the corrosion rate in the metal.[11]

In Priyotomo and Nuraini research (2016) it is stated that wuluh starfruit leaf extract (*Averrhoa bilimbi Linn*) can be used as an inhibitor of metal typed carbon steel corossion.[13] Saputri et al (2015) studied on nickel-titanium orthodontic wire with concentration of 600 ppm and 1000 ppm showed wuluh starfruit leaf extract (*Averrhoa blimbi Linn*) has the ability as inhibitor.[11]

Based on that description, the researcher is interested to investigate whether the wuluh starfruit leaf extract (*Averrhoa bilimbi Linn*) can decrease corrosion rate at stainless steel orthodontic wire in saline solution with addition of wuluh starfruit leaf extract (*Averrhoa bilimbi Linn*) at concentration of 600 ppm and 1000 ppm .

MATERIALS AND METHODS

Research permit and ethical clearance were made prior to the study published by the Faculty of Dentistry of Lambung Mangkurat No. 024/KEPKG-FKGULM/EC/VIII/2017. This study included true experimental research type with post-test only control group design. The sample in this research used stainless steel typed hard spring orthodontic wire with brand Dentaurum Germany. The number of samples was obtained using unpaired numerical analytical formula[17], which was 10 sample groups with a total of 30 pieces of wire. This study was divided into 3 groups consisting of one group as negative control, stainless steel orthodontic wire soaked in saline solution, two groups namely stainless steel orthodontic wire soaked in wuluh starfruit leaf extract of 600 ppm and 1000 ppm. All orthodontic stainless steel orthodontic wire samples were cut using 5cm cutting pliers and were scratched along the wire.

The Production of wuluh starfruit leaf extract

The process of extracting began by providing ripe wuluh starfruit leaves that obtained in Banjarbaru. This process was done at the Faculty of Mathematics and Natural Sciences of Universitas Lambung Mangkurat Banjarbaru. Wuluh starfruit leaf weighed as much as 1 kg and be washed. The leaves were aerated to become semi-dry. The leaves were put into oven with temperature 40^0C until they become dry. The leaves were blended into small pieces and sieved to powder.

Wuluh starfruit leaf macerated with 96% ethanol then stirred and closed tightly. Leaves were idle for 3x24 hours and stirred every day. The next step was separation between the pulp and filtrate by filtering the solvent to obtain the liquid extract of wuluh starfruit leaf. Liquid extract was put on rotary evaporator with temperature 50^oC and evaporated with waterbath in temperature of 50^0C to obtain thick wuluh starfruit leaf extract. Thick wuluh starfruit leaf extract obtained 47.93 grams.

The Production of wuluh starfruit leaf extract at concentration of 600 ppm and 1000 ppm

Thick wuluh starfruit leaf extract weighed in accordance with the required concentration, that is 600 ppm of 0,6000 grams and 1000 ppm of 1,0000 grams. The weighted extracts of each concentration were mixed into a 1000 ml saline solution and stirred until it mixed. The result of that dilution was wuluh starfruit leaf extract at concentration of 600

ppm as much as 1000 ml and 1000 ppm as much as 1000 ml.

Treatment of stainless steel orthodontic wire

Stainless steel orthodontic wire with a diameter of 0.7 mm cut along 50 cm, it made process to become easier to cast the wire. Stainless steel orthodontic wire was scratched along the wire using a diamond fissure bur with a speed of 500 rpm. The wire was scratched with a depth of 0.03 mm and cut along 5 cm. The wire was weighed using a digital scale and the wire diameter was measured using a digital caliver to obtain the same stainless steel orthodontic wire sample.

Measurement of corrosion rate

Measurement of corrosion rate was using potentiostat tool at Mechanical Engineering Laboratory of ITS Surabaya. The measurement process began with preparing a series of potentiostat equipment that had been connected to the computer. The solution was poured into a glass cup of 100 ml and was covered using a cover that having three holes as the site of the electrode.

The black port cable was connected to the Pt (platinum) electrode as the supporting electrode. The first red port cable was connected to the Ag / AgCl electrode as the reference electrode and the second red port cable was connected with stainless steel orthodontic wire which had been scratched as the working electrode. All three electrodes were inserted into the glass. The potential range was set at -600 mV to 600 mV with a measurement speed of 25 mV / s on Nova 1.8 software and the measurement was made until the corrosion rate was obtained.

RESULT

The mean result of stainless steel orthodontic wire corrosion rate measurement in the three groups obtained is as follows:

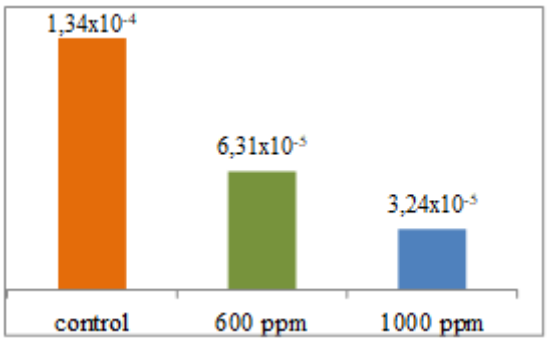

Figure 1. Graph of Average Results Measurement of Orthodontic Stainlees Steel Wire Corrosion Rate that Soaked in Saline Solution, Wuluh Starfruit Leaf Extract at Concentration of 600 ppm and 1000 ppm

Based on the corrosion rate measurement, it showed that the average corrosion rate of stainless steel orthodontic wire soaked in saline solution as control group is bigger than the of stainless steel orthodontic wire soaked in wuluh starfruit leaf extract in 600 ppm and 1000 ppm. The average corrosion rate of stainless steel orthodontic wire soaked in wuluh starfruit leaf extract of 600 ppm is greater than the corrosion rate of stainless steel orthodontic wire soaked in wuluhstarfruit leaf extract of 1000 ppm.

The results of the data continued with the processing and data analysis. The data obtained by performing Shapiro Wilk normality test. Based on the test results, it was obtained the significance value in the control group with p=0,087, wuluh starfruit leaf extract of 600 ppm with p=0,109 and wuluh starfruit leaf extract of 1000 ppm with p=0,940. The result of normality test shows the sample variable of stainless steel orthodontic wire in the three groups was normally distributed. The next test was carried out with Levene's Test homogeneity test. Based on the test result, it was obtained significance value on the three groups with p=0.066. The homogeneity test results showed the sample variables of stainless steel orthodontic wire in all three groups are homogeneous.

Based on the test result, it is obtained that the data in three groups were normally distributed and homogeneous. The test was then followed by One Way Anova parametric test. The test result showed significance value of p=0.000 (p <0.05) indicating

that there was significant difference between corrosion rate of stainless steel orthodontic wire that soaked in saline solution, wuluh starfruit leaf extract of 600 ppm and wuluh starfruit leaf extract of 1000 ppm.

Data from standard deviation result based on preliminary study and average of stainless steel orthodontic wire corrosion rate in all three groups can be seen in table 1 as follows:

Table 1. Average results and standard deviation

No	Group	Mean ± SD
1	Control	$1{,}34x10^{-4} \pm 1{,}24x10^{-5}$
2	600 ppm	$6{,}31x10^{-5} \pm 1{,}47x10^{-5}$
3	1000 ppm	$3{,}24x10^{-5} \pm 3{,}38x10^{-6}$

This results analysis was continued with Post Hoc test by using Bonferroni test in table 2 as follows:

Table 2. The results of the Bonferroni Post Hoc test

Group	**Control**	**600 ppm**	**1000 ppm**
Control	-	0,000*	0,000*
600 ppm	0,000*	-	0,000*
1000 ppm	0,000*	0,000*	-

* = there is a significant difference ($p < 0.05$)

The result of the test in table 2 shows that there was a difference between the stainless steel orthodontic wire group soaked in saline solution with wuluh starfruit leaf extract of 600 ppm. The result of the test shows that there was a significant difference between the stainless steel orthodontic wire group soaked in saline solution with wuluh starfruit leaf extract of 1000 ppm. The result of the test shows that there was a significant difference between the stainless steel orthodontic wire group soaked in wuluh starfruit leaf extract of 600 ppm with wuluh starfruit leaf extract of 1000 ppm.

DISCUSSION

The purpose of this research is to determine the ability of wuluh starfruitleaf extract to decrease the corrosion rate on stainless steel orthodontic wire. The average result of the stainless steel orthodontic wire corrosion rate between the control group and the treatment group in this research showed the highest corrosion rate in the control group. This result is consistent with the Ludiana and Handani (2012) study which states that the corrosion rate in the solution group having sodium and chloride without extract additional showed the highest corrosion rate compared to the group given the extract additional as inhbitor.[9]

The corrosive material is a material consisting of salt (salinity) such as sodium chloride.[15] The corrosion rate rises because Na and Cl presence in the solution can form metal bonds with ions. This will affect the state of the metal that can reduce the strength of metal bonding.[9] The reaction that occurs between the saline and Fe solution is as follows: [16]

$$Fe + 2\,NaCl \longrightarrow FeCl_2 + 2Na^+$$

The average corrosion rate of stainless steel orthodontic wire soaked in wuluh starfurit leaf extract at concentration of 600 ppm showed a reduced corrosion rate value compare to the stainless steel orthodontic wire group soaked in saline solution. This result is in accordance with Hermawan et al (2012) study who already proved that the average corrosion rate in the group with the extract at concentration of 600 ppm shows a lower corrosion rate than the group without the additional extract.[17] The decrease of corrosion rate occurs due to the formation of protective layer on the metal surface which can inhibit the rate exchange of ions in metal.[18]

The average corrosion rate of stainless steel orthodontic wire in the group soaked in wuluh starfruit leaf extract at concentration of 1000 ppm showed the lowest corrosion rate value compared to the stainless steel orthodontic wire group soaked in saline solution and wuluh starfruit leaf extract at concentration of 600 ppm. This result is in accordance with the research of Saputri et al (2015) which states that the average corrosion rate in the extract group with a concentration of 1000 ppm shows a lower corrosion rate than other concentrations and groups without the additional extracts.[11] Increasing the concentration of the extract will increase the complex compound formed so that the corrosion rate value will move in the lower direction due to the adsorbed inhibitor on other metal surface.[19] In this study, the concentration of wuluh starfruit leaf of 600 ppm

and 1000 ppm is included in the optimum concentration which can reduce the corrosion rate in stainless steel orthodontic wire.

Iron (Fe) is a transition metal with elemental properties that will form complex compounds. Iron has ions with empty orbitals so it can catch the pairs of electrons provided by the tannin compound.[21] The complexes compound formed can resist the attack of corrosive ions and will adsorb on the metal surface so that the corrosion rate becomes lower by forming a protective layer on metal surface.[17,11] Chemical reaction between tannin and Fe is as follows:[22]

$n\ Fe^{3+} + ne^{-} \leftrightarrow nFe^{2+}$

tannins $\leftrightarrow$ *tannate* $+ ne^{-} + nH^{+}$

$n\ Fe^{3+}$ + *tannins* $\leftrightarrow (Fe^{2+})_n$ tannate $+ nH^{+}$

Several studies have shown other compounds that can act as inhibitor is flavonoid. Flavonoids have hydroxyl groups that can form complex compounds on metal surfaces.[23] Other content that contained in wuluh starfruit leaf is tannin. Tanin is a non-toxic substance that has a hydroxyl functional group (OH) and attaches to an aromatic ring.[19] Tannins have a free electron pair so it can give their electrons to the metals to form complex compounds.[20] Based on the research results, it has been concluded that wuluh starfruit leaf extract is able to decrease corrosion rate where the highest reduction of corrosion rate can be found in wuluh starfruit leaf extract at concentration of 1000 ppm group.

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