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The Effect Of Green Betel Leaf (Piper Betle Linn) Ethanol Extract On The Corrosion Rate Of Nickel Titanium Wires

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Abstract:
Background*: Nickel titanium wire is one of active component in orthodontic treatment. It placed in in the oral cavity and will contact with all elements in oral cavity for long period of time, especially saliva, which affects metal properties of orthodontic wire. The wire in oral cavity undergoes a corrosion process that results in the detachment of the metal elements that make up the wire. Green betel leaf ethanol extract (Piper betle Linn) consist of flavonoids, tannins, alkaloids, and saponins which have anti-inflammatory and antioxidant properties. These compounds will form a protective film on metal surface through the adsorption of ions to the metal surface.*
Material and methods: *This research was experimental laboratory with a research group consisting of 27 nickel- titanium orthodontic wire, divided into 9 groups, namely 3 negative control groups immersed in artificial saliva, 3 positive control groups immersed in chlorhexidine 2%, and 3 treatment groups immersed in Green betel (Piper betle Linn) leaf ethanol extract. Each group has 3 samples and immersed on 1, 7, and 14 days. The corrosion rate was measured by weight loss method using analytic digital scale.*
Result: *Mean value data showed decreasing corrosion rate in all groups from the 1st day to the 14th day. Results shows there was significant difference between groups ($p<0.05$).*
Conclusion: *The composition of green betel leaf extract was resulting on reducing the corrosion rate of nickel-titanium wires by forming a passive layer on the metal surface that can protect metal from further corrosion processes.*
Key Word: *Nickel-Titanium wire; Piper betle Linn ethanol extract; Corrosion rate.*

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I. Introduction

Orthodontic treatment aims to achieve a good and stable occlusal relationship. Orthodontic wire is one of the main components in fixed orthodontic treatment. It has important role is to correct position of teeth in the mouth, so the wire must be produced accurately, both in terms of shape, strength and corrosion resistance levels and biocompatibility.[1,2]

The wire in oral cavity may undergo corrosion processes which resulted loss of metal elements.[3] Pataijindachot et al., (2018) reported that the corrosion rate of nickel titanium orthodontic wire immersed in artificial saliva solution pH 2.5 and pH 6 measured at as-received and 90 days, showed that corrosion rate in lower pH solution has greater corrosion rate, and between as-received an 90 days immersion time showed greater corrosion rate at 90 days. It indicates that lower pH and longer immersion time can lead to higher corrosion rate.[4] This corrosion can caused damage to the orthodontic appliance either physically or chemically. Corrosion caused loss of substance in the material, changes in structural characteristics, or loss of structural integrity. In addition corrosion could increase the surface roughness of the wire, increasing frictional stress between wire and bracket. An increase frictional stress can lead to an unfavorable distribution of forces, decreasing effectiveness of tooth movement in orthodontic treatment, as well as potentially increasing failure of orthodontic treatment.[5]

Nowadays, there are many studies that discuss natural ingredients that can be used in dental health products such as mouthwash. WHO recommends and promotes traditional or herbal medicines in national health care plans because they are easy to obtain, cheaper, safer and have no harmful side effects. Currently, many plants have antibacterial properties, one of which is the green betel leaf *(Piper betle Linn*).[6]

Green betel leaf (*Piper betle Linn*) contains high antioxidants substances such as flavonoids and tannins. Polyphenolic compounds contained in tannins could inhibit the oxidation process. Polyphenols have antioxidant activity that serves as a catcher and binder of free radicals from the destruction of metal ions. Flavonoids and tannins could form a protective layer on the metal surface through the adsorption of ions to the

metal surface.[7] In addition, various studies related to the benefits of green betel leaf on the oral cavity have often been reported so that the use of this plant could continue to be developed. This study report measured the corrosion rate of nickel-titanium wires immersed in chlorhexidine and Piper betle Linn ethanol extract. These results will help dentist to prescribe the best mouthwash for their patient's needs.

II. Material And Methods

Twenty-seven 0.016 inch nickel-titanium orthodontic wires (American Orthodontics, USA) with 5 cm length used as samples. The wires divided into 9 groups. Each group immersed for 1, 7, and 14 days in different solutions. Group 1-3 is a control group that immersed in artificial saliva. Group 4-6 immersed in chlorhexidine mouthwash 0.2%. Group 7-9 immersed in Piper betle Linn extract 1%. Each wire was placed in individual polypropylene tube containing 10 mL of immersion solution and incubated at 37ºC for 1, 7, and 14 days. After incubation, each sample was measuredwith weight loss method.

Study Design: Post test only control group design.

Study Location: Piper betle Linn ethanol extract was made in Laboratorium Fitokimia Farmasi, Universitas Sumatera Utara. Identification of Piper betle Linn leaves was made in Laboratorium Sistematika Tumbuhan Herbarium Medanense (MEDA), Universitas Sumatera Utara. Analytic digital scale to measured wire's weight was made in Laboratorium Mikrobiology , Faculty of Pharmacy, Universitas Sumatera Utara.

Study Duration: September 2022 to February 2023.

Sample size: 27 nickel-titanium wires.

Sample size calculation: Amount of sampel (r) was calculated according to Federer's formula: $(t-1)(r-1) \geq 15$, where

(t) is amount of groups. Since (r) = 2.875, equal to three samples for each group. The wires divided into 9 groups, total of sample is 27. Twenty-seven 0.016 inch nickel-titanium orthodontic wires (American Orthodontics, USA) with 5 cm length used as samples.Each group immersed for 1, 7, and 14 days in different solutions (Group 1-3 : negative control group, Group 4-6 : positive control group, Group 7-9: treatment group).

Subjects & selection method: The study samples are new nickel titanium wire from sealed packaging and have ISO (International Organization for Standardization) standard. Samples are not expiry which is expiration date is officiallyprinted in the package. Each sample which are selected has no defect.

Samples are divide into :

Group 1 (N=3) - immersed in 10 ml artificial saliva and incubated at 37ºC for 1 day; Group 2 (N=3) - immersed in 10 ml artificial saliva and incubated at 37ºC for 7 days; Group 3 (N=3) - Immersed in 10 ml artificial saliva and incubated at 37ºC for 14 days.

Group 4 (N=3) - immersed in 10 ml chlorhexidine mouthwash 0.2% and incubated at 37ºC for 1 day; Group 5 (N=3) - immersed in 10 ml chlorhexidine mouthwash 0.2% and incubated at 37ºC for 7 days; Group 6 (N=3) - immersed in 10 ml chlorhexidine mouthwash 0.2% and incubated at 37ºC for 14 days; Group 7 (N=3) - immersed in 10 ml Piper betle Linn extract 1% and incubated at 37ºC for 1 day; Group 8 (N=3) - immersed in 10 ml Piper betle Linn extract 1% and incubated at 37ºC for 7 days; and Group 9 (N=3) - Immersed in 10 ml Piper betle Linn extract 1% and incubated at 37ºC for 14 days.

Inclusion criteria:

1. Nickel titanium orthodontic wire from sealed packaging
2. Nickel-titanium orthodontic wires with 0.016 inch diameter and 5 cm length

Exclusion criteria:

1. Defect and expired nickel titanium orthodontic wires

Procedure methodology

After incubation of groups 1-9 for 1, 7, 14 days, each sample was measured with weight loss method. The method of weight loss is a method of calculating the corrosion rate carried out by measuring the lack of wire weight due to corrosion. This method generally uses a period of research in order to find out how much weight loss in a medium is due to corrosion in the medium. The sample is placed inside the system and left to corrode. After that, the corrosion rate is calculated through the weight loss that occurs in the sample. Weight

measurement is carried out using analytical digital scales for three times the averaged it. The corrosion rate of the wire was calculated with the following formula : CR = (K (Wb-Wa))/(D.S.T), where CR is the corrosion rate; Wb and Wa are the weight of specimens before and after exposure respectively, D is indicates the Density (g/cm3), S indicates the total surface area (cm2), and T is the time exposure (hour). The data were added at the table.[8]

Statistical analysis

Data was analyzed using SPSS version 20 (SPSS Inc., Chicago, IL). The normality of distribution test was carried with the Shapiro-Wilk test. The data obtained were not normally distributed, then it continued with the Kruskal-Wallis test. A significant values (p<0,05) showed that there were significant differences in each group.[9]

III. Result

After immersion in 1, 7, and 14 days, the data were averaged in table (Table 1). The highest corrosion rate was in the 1st day artificial saliva group. Based on the table 1, it was also known that the all group experienced an decrease fromthe 1st day to the 14th day.

Table no 1: The results of the calculation of the average number of corrosion rate and the value of standar deviation.

Group	1st day (mean±SD)	7th day (mean±SD)	14th day (mean±SD)
Artificial saliva	5,607±1,942	1,655±0,403	1,468±0,122
Chlorhexidine 2%	7,102±0,647	2,510±0,245	2,243±0,160
Piper betle Linn 1%	5,233±1,713	0,587±0,333	0,240±0,080

A non-parametric test (Kruskal-Wallis) in table 2 showed the corrosion rate of nickel titanium statistically has not significantly difference in artificial saliva among 1, 7, and 14 days group p=0,061 ; in chlorhexidine has significantly differentce p=0,043 (p<0,05); in Piper betle Linn has significantly difference p=0,032 (p<0,05).

Table no 2 : Shows Kruskal-Wallis test in immersion solution groups.

Groups (solution)	Immersion time(day)	n	p
Artificial saliva	1	3	0,061
	7	3	
	14	3	
Chlorhexidine	1	3	0,043*
	7	3	
	14	3	
Piper betle Linn	1	3	0,032*
	7	3	
	14	3	

*p<0,05

This research not only report based on type solution but also based on immersion time (Table 3). Kruskal- Wallis test reported the corrosion rate statistically has significantly difference in artificial saliva, chlorhexidine and Piper betle Linn for 7 days p=0,027 (p<0,05), 14 days p=0,027 (p<0,05).

Table no 3 : Shows Kruskal-Wallis test in immersion times groups.

Immersion time (day)	Solution	n	p
1	Artificial saliva	3	0,207
	Chlorhexidine	3	
	Piper betle Linn	3	
7	Artificial saliva	3	0,027*
	Chlorhexidine	3	
	Piper betle Linn	3	
14	Artificial saliva	3	0,027*
	Chlorhexidine	3	
	Piper betle Linn	3	

*p<0,05

IV. Discussion

This research was conducted to examine the corrosion rates of nickel-titanium orthodontic wires in artificial saliva, chlorhexidine, and *Piper betle Linn* ethanol extract. The results showed that there is a significant differences in the effects of *Piper betle Linn* ethanol extract on the corrosion rate of nickel-titanium orthodontic wires. The results indicates that *Piper betle Linn* ethanol extract was influential in slowing down the corrosion

rates of nickel-titanium orthodontic wires. The highest average rate of corrosion was identified in chlorhexidine group, while the lowest average rate of corrosion was identified in treatment group (*Piper betle Linn* ethanol extract). There is a significant difference in corrosion rate between nickel-titanium orthodontic wires immersed in artificial saliva solution as negative control group, chlorhexidine 0.2% mouthwash as positive control group, and green betle leaf (*Piper betle Linn*) ethanol extract as positive control group for 1, 7, and 14 days.

Table 1 shows the average corrosion rate of nickel-titanium orthodontic wire immersed in 0.2% chlorhexidine solution has the highest value compared to wire immersed in artificial saliva and *Piper betle Linn* ethanol extract at 1, 7, and 14 days. The results of this study are in line with Moeen et al. research, which reported the corrosion rate of nickel-titanium wire after immersed in 3 different mouthwash solution and artificial saliva solution as control. The results showed that the highest corrosion rate was found in the wire immersed in 0.2% chlorhexidine mouthwash followed by SecureTM, Hi-ParadentTM, and artificial saliva as the control group. Chlorhexidine causes corrosion because it is acidic or has a low pH. The acidity of the solution is proportional to the concentration of hydrogen ions, so the more acidic a solution will be containing a higher concentration of hydrogen ions. Hydrogen ions will trigger a reduction reaction so that more and more metal ions are oxidized which accelerates the corrosion process.[10]

In this study, the highest mean corrosion rate was found on day 1 and then decreased at 7 and 14 days. This results are relevant with the research of Novita et al., which reported that the corrosion rate of stainless steel immersed in NaCl and H_2SO_4 for 7 Days, 14 days, and 21 days decreased. The hardness of the sample decrease after corrosion. This is because there are other elements that make the metal susceptible to corrosion. In addition, the increases of immersion time, corrosion rate tends to decrease due to passivation, which formed corrosion products on the surface. The presence of corrosion products on the surface of sample can reduce corrosion process on the surface of wire because rust layer serves as a diffusion barrier that can reduce the rate of reduction of dissolved oxygen.[11]

Kruskal-Wallis test indicated that there was a significant differences among experimental groups. Thus, *Piper betle Linn* ethanol extract is influential in slowing down the corrosion rate of stainless steel orthodontic wires was proven. The decrease in the average rate of corrosion in nickel titanium orthodontic wires was caused by active compounds in green betel leaf extract. Several chemical compounds are present in the green betle leaf such as tannin, alkaloid, saponin, flavonoid, and phenol. Some studies identify that tannins can be used as natural inhibitors. Tannins are useful as corrosion inhibitors by forming complex compounds with metal ions, which form a thin protective film on the surface of nickel titanium orthodontic wires. This thin layer prevents corrosive chloride ions in saliva from damaging the surface of the nickel titanium wire.

Corrosion in orthodontic appliances is a form of problem that is constant and difficult to eliminate, but can be prevented.[12] Generally metals have high corrosion resistant properties. But the state of the oral cavity, such as low pH, the presence of plaque, and the use of mouthwashes containing fluoride and chloride can provoke corrosion. Pitting corrosion is the most common type of corrosion in fixed orthodontic appliance due to the nature of saliva chloride ions or from food and drink.[13] Inorganic components that are in saliva act as electrolyte media that can trigger electrochemical reactions. Electrochemical reactions are reactions that occur at the anode (oxidation) and cathode (reduction), where metal ions as the anode and H^+ ions from the electrolyte medium as the cathode. As a result, the release of metal ions resulting in corrosion.[14]

Prevention of corrosion of orthodontic wire can be done by involving a good corrosion inhibitor that is organic.[11] Green betel leaf ethanol extract (*Piper betle Linn*) produces a lower corrosion rate than chlorhexidine 0,2% mouthwash. This is because Green betel leaf ethanol extract (*Piper betle Linn*) has high content of antioxidants in green betel leaf *(Piper betle Linn*) such as flavonoids and tannins.[6] Polyphenolic compounds contained in tannins can inhibit the oxidation process. Polyphenols have antioxidant activity that serves as a catcher and binder of free radicals from the destruction of metal ions. Flavonoid and tannin compounds can form a protective layer on the metal surface through the adsorption of ions to the metal surface, so it can be considered as an alternative herbal mouthwash for orthodontic patients.[7]

V. Conclusion

Studies of corrosion phenomena are very important. Indeed, the materials used in the study are biocompatible. However, some" extreme " conditions of the oral environment when the wire and bracket contact can cause corrosion phenomena. Green betel leaf ethanol extract (*Piper betle Linn*) could inhibit the corrosion rate of nickel titanium orthodontic wires, because the content in green betel leaf ethanol extract (*Piper betle Linn*) contains tannins that can function as inhibitors of the metal ions release. The nature of tannins can be soluble in water or alcohol causing tannins can bind heavy metals. The presence of tannins can prevent the release of metal ions orthodontic wire. Flavonoids can capture free radicals by freeing hydrogen atoms from their hydroxyl groups. The presence of electronegative atoms and double bonds of alkene group gives the extract potential as a corrosion inhibitor.

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