

The Effect Of Herbal Toothpaste With Siwak Extract On The Tensile Force Of Orthodontic Elastomer Power Chain Elastomers

Pengaruh Perendaman Pasta Gigi Herbal Dengan Ekstrak Siwak Terhadap Gaya Regang *Power Chain* Elastomer Ortodontik

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ABSTRACT

Power chain elastomers are one of the most commonly used devices in orthodontic treatment. Recently, herbal toothpaste containing siwak extract has been developed, which shown to be more effective in reducing plaque index compared to non-herbal toothpastes. However, siwak extract contains fluoride that may reduce tensile force. This study aimed to analyze the effect of herbal siwak toothpaste and non-herbal toothpaste on the tensile force of orthodontic power chains elastomers. A total of 144 power chain elastomer specimens were immersed in treatment groups, Aquadest and Pepsodent® Complete 8 Siwak toothpaste solution, Aquadest and Pepsodent® toothpaste solution, and Aquadest as the control group. The tensile force of the power chain elastomer was measured using a Universal Testing Machine (UTM) after immersion for 6, 42, 84, 126, and 168 minutes. The data were analyzed using one way ANOVA test. The result showed that after the immersion, the tensile force of power chain elastomers in aquadest, non-herbal toothpaste, and herbal siwak toothpaste were significantly different ($p < 0,05$). Herbal siwak toothpaste caused a smaller reduction in the tensile force of the orthodontic power chain elastomers compared to non-herbal toothpaste. It can be concluded that immersion in herbal siwak toothpaste results in a greater reduction in tensile force compared to the control group, which was immersed in Aquadest.

Keywords: Siwak Herbal toothpaste, tensile force, orthodontic power chain elastomers

ABSTRAK

Power chain elastomer merupakan salah satu piranti yang paling umum digunakan dalam perawatan ortodontik. Saat ini, telah dikembangkan pasta gigi herbal dengan ekstrak siwak yang secara lebih efektif dapat menurunkan indeks plak dari pasta gigi nonherbal. Namun, ekstrak siwak mengandung *fluoride* yang dapat menyebabkan penurunan gaya regang. Studi ini dimaksudkan guna mengetahui pengaruh penggunaan pasta gigi herbal siwak dan non-herbal pada gaya regang dari *power chain* elastomer ortodontik. Sebanyak 144 spesimen *power chain* elastomer direndam dalam kelompok perlakuan, yaitu larutan akuades dan Pasta gigi Pepsodent® Complete 8 Siwak, larutan akuades dan pasta gigi Pepsodent® pencegah gigi berlubang, dan Akuades sebagai kelompok kontrol. Gaya regang *chain* elastomer diukur menggunakan UTM setelah perendaman selama 6, 42, 84, 126, dan 168 menit. Data dianalisis menggunakan uji *one way anova*. Hasil penelitian setelah perendaman selama 42, 84, 126, dan 168 menit, ditemukan besar gaya regang *power chain* elastomer yang berbeda secara signifikan pada perendaman akuades, pasta gigi non herbal, dan pasta gigi herbal siwak ($p < 0,05$). Pasta gigi herbal siwak menyebabkan penurunan gaya regang *power chain* elastomer ortodontik yang lebih kecil dari pasta gigi nonherbal. Dapat disimpulkan bahwa perendaman dalam pasta gigi herbal siwak menghasilkan penurunan gaya regang yang lebih besar dibandingkan dengan kelompok kontrol yang direndam dalam akuades.

Kata Kunci: Pasta gigi herbal siwak, gaya regang, *power chain* elastomer ortodontik.

INTRODUCTION

Orthodontic elastomer chain is one of the active components of fixed orthodontic appliances, which has the function of attaching the arch wire to the bracket.¹ Elastomer is a term meaning a material that, after undergoing large deformation, can quickly return to its original dimensions.² There are three forms of elastomer power chains, namely short (open), long (wide), and closed (continuous), which can be seen in Figure 1.³ Closed chains have no gaps between the chains and produce the greatest initial force.⁴ Short chains have less spacing between the chains and provide lower force.⁴ Longer chains provide even lower forces, and the distance between the links is longer.⁴

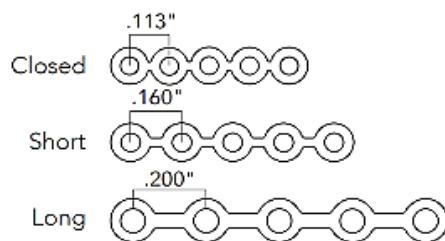


Figure 1. Types of Power Chains⁵

Chain elastomer is a polymer with a high molecular weight.³ Although the detailed composition is usually kept secret by manufacturers, it is known that most orthodontic elastomer chains are made from clear resin or synthetic rubber, namely polyurethane.⁶ Because it is made of polyurethane, chain elastomer has the property of being easily stretched and can return to its original length after being stretched to a certain limit due to internal stress.⁷ The tensile strength can decrease over time. The most frequent decrease in tensile strength occurs when it is first stretched and in the first 24 hours, but then it slows down and tends to be more stable.⁷ In addition, the elastomer chain is also hydrophilic, so it can interact with saliva and damage internal bonds.⁸ This causes changes in physical properties, including a decrease in tensile strength.⁸

The use of elastomers in orthodontic treatment causes the elastomer to be exposed to various conditions in the oral cavity, such as temperature, humidity, and the patient's food consumption, which can affect the effectiveness of the chain elastomer.⁴ Many factors, both

internal and external, can affect the reduction of force in elastomer chains. Internal factors include material composition, production method, and physical form, while external factors include humidity.⁹

Tooth movement, salivary enzymes, alcohol-containing mouthwashes, whitening mouthwashes, alkaline solutions, and strong acids (pH<5.4) can significantly reduce the force on the elastomer chain.¹⁰ Increasing temperature can increase the reduction in the elastomer force.¹¹ Orthodontic elastic materials show decreased tensile forces after mastication and mechanical brushing.¹² Different manufacturing techniques can also affect the mechanical properties of elastomeric chains, for example, chains with "high memory" characteristics can provide a more constant tensile force, can maintain a force of 20%-30% more than conventional elastomeric chains.¹³ Abrasive materials can cause more water absorption and permanent deformation of the elastomer, resulting in a decrease in tensile strength.⁵

Toothpaste or gel is used to maintain and improve oral health and freshen breath.¹⁴ Toothpaste is used in conjunction with a toothbrush for mechanical cleaning.¹⁴ Toothpaste contains active ingredients, namely fluoride and antimicrobials, which can remove bacteria and debris from teeth, thereby preventing oral diseases.¹⁵ One of the herbal toothpastes is a toothpaste made from natural ingredients, including siwak.¹⁶

Herbal toothpaste is an alternative that is currently becoming increasingly popular because it contains natural herbal active ingredients, making it safe to use.¹⁰ Previous research by Nuraskin *et al.* showed that there was a significant average difference in both types of herbal and non-herbal toothpaste in reducing the dental plaque index. The use of herbal toothpaste was stated to be more effective than non-herbal toothpaste in reducing plaque.¹⁷

The method of cleaning teeth with chewing materials is used in many developing countries. Miswak (*Salvadora persica*) is the plant most often used for this method.¹⁸ Siwak contains trimethylamine (TMA), which can be antibacterial and prevent plaque formation, salvadorine and chloride, which can prevent calculus formation, fluorine as an anticarcinogenic, silica as an abrasive, sulfur,

mustard oil, vitamin C, resin, tannin, saponins, flavonoids and sterols.¹⁹ In addition, siwak also has mild effects as a laxative, antipyretic, anti-inflammatory, diuretic, astringent and analgesic.²⁰

Evidence was found that toothpaste with siwak was more effective in reducing plaque index than non-herbal toothpaste, and there was no significant difference when compared with brushing teeth using real siwak.⁷ Miswak extract in toothpaste has antibacterial power on *Streptococcus mutans* and contains SCN- which reacts with sulfhydryl groups in bacterial enzymes, causing bacteria to die.⁷ This causes no formation of acid products, and a decrease in plaque pH and pH in the oral cavity does not occur. The silica content as an abrasive in toothpaste with miswak extract can cause permanent deformation of the elastomer, causing a decrease in tensile strength.⁵

The tensile force test is performed by pulling a material with a certain force. This test is a method used to measure the strength and elasticity of a material when given a tensile force.²¹ In the context of orthodontics, this test is important to be performed on elastomer chains to determine the ability of the elastomer chain to provide force and withstand tensile force during the treatment process.²² The tensile force of the elastomer chain can be measured using a tool in the form of a UTM or Universal Testing Machine by pulling both ends of the power chain specimen on the tensile force jig in Newton units^{23,24}

RESEARCH METHODS

A total of 144 orthodontic elastomer power chain specimens were used with a closed type, gray color, 4 lumen size or 11 mm long (American Orthodontics, USA). The elastomer power chain specimens were subjected to 3 treatments, namely Pepsident® Complete 8 Siwak toothpaste (LOT: 62717513), Pepsident® Cavity Prevention toothpaste (LOT: 69709288) distilled water.

The soaking solution was prepared by mixing 200 mL of distilled water and 125 grams of toothpaste, based on the formulation used in a study by Behnaz M *et al.*³⁴ The elastomer power chain was mounted on an acrylic plate (Figure 2) and soaked in the treatment for 6, 42, 84, 126, and 168 minutes in a shaking incubator at 37°C to simulate the

exposure conditions of toothpaste to the power chain when brushing teeth twice a day for 3 minutes in 1 day, 1 week, 2 weeks, 3 weeks, and 4 weeks. The selection of these durations was based on the optimal toothbrushing time, which is around 3 minutes twice daily.³⁵ Additionally, the greatest reduction in tensile force was observed within the first 24 hours of exposure, while subsequent reductions tended to be smaller and more stable by the third and fourth weeks of immersion.^{7,28}

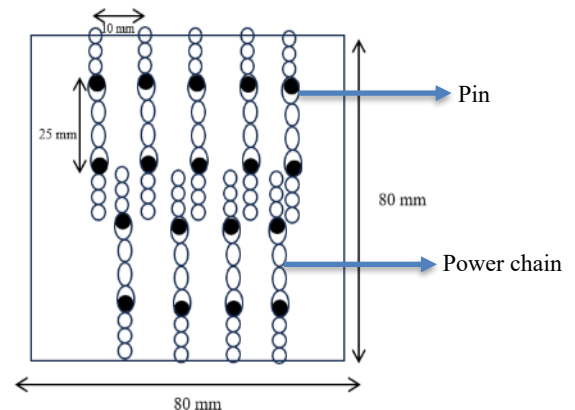


Figure 2. Acrylic Plate Model Equipped with Pin and Power Chain.

Tensile force measurements were carried out using a Universal Testing Machine (Shimadzu AGS-5kNX™), with a speed of 30 mm/min and a load of 5000 N. The percentage change in tensile force was calculated using the formula:

$$\% \text{ change in tensile force} = \frac{\text{Initial and final tensile force difference}}{\text{Initial tensile force}} \times 100\%$$

THE IBM SPSS Statistics 27.0 application was used to perform data analysis. A normality test was performed with the Shapiro-Wilk test and a homogeneity test with the Levene test. After that, a GLM repeated-measure test was performed on normally distributed data and non-normal data, Friedman test was performed to determine the level of significance before and after immersion. On normally distributed data, a One-Way ANOVA test was performed, but on non-normally distributed data, a Kruskal- Wallis test was performed to determine the level of significance of the difference in tensile force changes in each treatment group.

RESULT

The results of the study showed a decrease in tensile force that varied in each immersion medium and with different immersion durations. The magnitude of the tensile force and the percentage of decrease in the tensile force of the power chain are shown in Figure 3 and Table 1. In the control treatment group, namely immersion in distilled water, all groups between immersion durations of 0 to 168 minutes showed a statistically significant decrease in tensile force ($p < 0.05$). The non-herbal toothpaste immersion treatment group also showed a statistically significant decrease in tensile force ($p = 0.0001$), as well as immersion in herbal toothpaste solution with siwak extract.

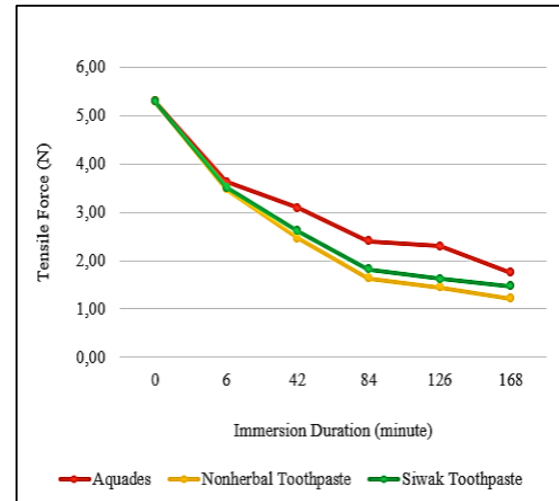


Figure 3. Tensile Force of Power Chains over Immersion Durations in Aquades, Nonherbal Toothpaste, and Herbal Siwak Toothpaste

Table 1. Mean Values and Tensile Force Decay Percentage of Power Chains after Immersion in Aquadest, Nonherbal Toothpaste Solution, and Herbal Siwak Toothpaste Solution at Each Time Interval

Immersion Duration	n	Aquadest		Nonherbal Toothpaste		Herbal Siwak Toothpaste		P-value
		Tensile Force (N) $\pm$ SD	Force Decay (%)	Tensile Force (N) $\pm$ SD	Force Decay (%)	Tensile Force (N) $\pm$ SD	Force Decay (%)	
0 minute	9	5,29 $\pm$ 0,07 ^a	0%	5,29 $\pm$ 0,07 ^a	0%	5,29 $\pm$ 0,07 ^a	0%	P=0,0001*
6 minute	9	3,62 $\pm$ 0,08 ^b	31,56%	3,47 $\pm$ 0,05 ^c	34,4%	3,50 $\pm$ 0,08 ^c	33,83%	P=0,0001*
42 minute	9	3,09 $\pm$ 0,07 ^d	41,58%	2,46 $\pm$ 0,05 ^e	53,49%	2,62 $\pm$ 0,07 ^f	50,47%	P=0,0001*
84 minute	9	2,40 $\pm$ 0,06 ^g	54,63%	1,63 $\pm$ 0,07 ^h	69,18%	1,82 $\pm$ 0,06 ⁱ	65,59%	P=0,0001**
126 minute	9	2,29 $\pm$ 0,06 ^j	56,71%	1,44 $\pm$ 0,05 ^k	72,77%	1,62 $\pm$ 0,07 ^l	69,37%	P=0,0001*
168 minute	9	1,75 $\pm$ 0,05 ^m	66,91%	1,21 $\pm$ 0,04 ⁿ	77,12%	1,47 $\pm$ 0,04 ^o	72,21%	P=0,0001*
P-value		P=0,0001***		P=0,0001****		P=0,0001****		

* One-Way ANOVA test: different superscript letters indicate statistically significant differences between treatment groups within the same immersion duration.

** Kruskal-Wallis test: different superscript letters indicate statistically significant differences between treatment groups within the same immersion duration.

*** Friedman test: different superscript letters indicate statistically significant differences in immersion durations of 0, 6, 42, 84, 126, and 168 minutes.

**** GLM Repeated Measures test: different superscript letters indicate statistically significant differences in immersion durations of 0, 6, 42, 84, 126, and 168 minutes.

DISCUSSION

During the treatment, the power chain specimen was stretched along 25 mm on an acrylic plate. Eliades *et al.* in Al-Kassar stated that during stretching, the elastomer molecular chain also experiences stretching. When stretching continues, elastic deformation is inhibited, and irreversible permanent deformation occurs so that the elastomer experiences permanent elongation and

decreased elasticity.²⁵ The force applied during stretching causes the molecules in the polymer that were previously spiral-shaped to straighten or unravel. The molecules shift relative to each other, and a permanent change in structure or deformation occurs.²⁶ In this process, a pattern of tears and microfractures is formed from the edge to the inside of the material following the direction of the load or what is known as the

"Aging Phenomenon," thereby reducing the elastomer's ability to provide tensile force.²⁷

The duration of immersion in the three treatment groups also gave different magnitudes of force reduction. In the first 6 minutes of immersion, there was the largest decrease in tensile force in all power chain groups, and the magnitude of the decrease in tensile force in the following durations (42, 84, 126, and 168 minutes) tended to experience a smaller decrease. The results of research by Nakhaei *et al.*⁷ and Aldrees *et al.*²⁸ stated that in the first 24 hours, there would be the largest decrease in tensile force, and tended to be smaller and stable after immersion in the 3rd and 4th weeks.^{7,28} So, the duration of immersion affects the decrease in the tensile force of the power chain. In the first 6 minutes, the tensile force of the power chain made of polymer begins to degrade due to deformation, so that the decrease in tensile force occurs in large amounts. After 6 minutes, the elastomer material is more brittle and loses elasticity, and most of the permanent deformation has occurred in the elastomer, so that the tensile force tends to be constant.²⁹

The three treatment groups caused a decrease in the tensile strength of the elastomer power chain, also due to the nature of the elastomer that absorbs water, so that hydrogen atoms enter the polyurethane molecules in the elastomer. Hydrogen ions in water will bind to oxygen in the polyurethane and cause microscopic swelling of the polymer.⁸ The magnitude of the tensile force of the elastomer power chain after being soaked in toothpaste solution, both non-herbal and herbal siwak, was significantly smaller compared to soaking in distilled water ($p=0.0001$). This occurs because the fluorine ions in the toothpaste interact with the hydroxyl groups found at the end of the polyurethane chain and cause the breaking of the bonds of the polyurethane molecular chains.³⁰ Babra T *et al.*³¹ research shows that fluorine can trigger the degradation of polyurethane, which results in a significant decrease in molecular weight from 26.1 kg/mol to 6.2 kg/mol due to chain cleavage.³¹ This is in line with the study by Sadeghian S *et al.*²⁶ that immersing chain elastomer in mouthwash with fluoride causes a greater reduction in tensile force compared to immersion in artificial saliva and mouthwash without fluoride.²⁶

In this study, it was found that the decrease in tensile force on the elastomer power chain after immersion in herbal toothpaste with siwak extract was significantly smaller than non-herbal toothpaste ($p = 0.0001$). This can occur due to differences in the composition of composition in non-herbal toothpaste and herbal siwak toothpaste. Herbal ingredients such as siwak extract have minimal influence and react to the power chain, so that they are safer and can minimize unwanted side effects.³² Miswak extract is rich in polyphenol compounds, namely tannins and flavonoids, as antioxidants. Polyphenols can reduce the negative effects of the aging process by eliminating free radicals, thereby minimizing oxidative degradation in elastomers.³³ The incorporation of polyphenol compounds into elastomers can increase stability, reduce bond changes, and maintain mechanical properties, which ultimately increases resistance to aging and oxidation effects on elastomers. Research by Omidkhoda *et al* (2015) stated that herbal mouthwash siwak caused the smallest decrease in force of 43.19%, compared to fluoride mouthwash of 56.81%, and chlorhexidine mouthwash caused a greater decrease in tensile force of 59.85%. Therefore, herbal toothpaste with siwak extract can be a good choice for users of fixed orthodontic appliances with elastomer power chains to minimize decrease in the tensile force of the power chain, the treatment can be more effective without reducing oral hygiene, considering that herbal siwak toothpaste more effective in reducing plaque index than non-herbal toothpaste.¹⁷

The findings suggest that choosing toothpaste formulations with minimal reactive potential, such as herbal siwak toothpaste, may help preserve the mechanical performance of elastomeric power chains over time. This could contribute to more consistent orthodontic force delivery, potentially improving treatment efficiency and reducing the frequency of appliance replacement. For clinicians, these results highlight the importance of considering oral hygiene product composition when advising orthodontic patients.

Beyond the mechanical properties evaluated in this study, exposure to various toothpaste formulations with sodium lauryl sulfate (SLS) and abrasives like silica can affect other important characteristics of elastomeric power chain, particularly color stability and

chemical structural changes.³⁶ Orthodontic elastomeric power chains are made from polyurethane, that can be reactive to break down when exposed to water, enzymes, heat, and humidity over extended periods.³⁷ As a result, power chain may become discolored when they are exposed to certain substances.

The chemical structure of power chain can also be affected by environmental conditions, including water containing in toothpaste. The attractive force between the hydrogen atoms in water and the oxygen atoms in the power chain causes small molecules in water to be drawn into the polymer chains. The absorbed water fills the spaces between polymer chains, increasing the distance between them.^{38,39} Discoloration of the power chain can affect patient satisfaction and aesthetic outcomes, while chemical changes may further compromise its mechanical integrity over time. Although these parameters were not evaluated in the present study, previous literature has shown that exposure to certain oral hygiene products, such as toothpaste and mouthwash, can accelerate both discoloration and chemical breakdown of elastomeric materials.³⁶

This study presents several limitations that should be considered when interpreting the results, including The experiment was conducted under in vitro conditions, which do not fully replicate the condition of the oral cavity, including fluctuations in temperature and pH, salivary enzyme activity, and mechanical forces from mastication. The study focused solely on measuring the change in tensile force. Other potential effects, such as color changes or chemical alterations of the power chain, were not evaluated.

CONCLUSION

By the limitations of this research, it can be concluded that immersion in distilled water, non-herbal toothpaste solution, and herbal siwak toothpaste can cause a decrease in the tensile force of the orthodontic elastomer power chain. Immersion in the Pepsodent® brand herbal siwak toothpaste solution causes the tensile force of the orthodontic elastomer power chain to decrease more than immersion in distilled water, but less than non-herbal toothpaste.

SUGGESTION

From the results of this study, further research is needed, namely research using the brushing method to determine the effect of herbal toothpaste siwak mechanically on the tensile force of the elastomer power chain. In addition, trials with other types of power chains, namely short (open) and long (wide) elastomer power chains are also needed. Moreover, future research should consider conducting an in vivo design to more accurately simulate the conditions of the oral environment, as the limitations of the current in vitro model might not accurately represent the oral environment. Future studies should also evaluate other potential effects, such as color stability and chemical changes of the power chain, to provide a more comprehensive understanding of the material's behavior under various oral conditions and herbal siwak toothpaste effect.

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