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The effect of tobacco leave pastes (*Nicotiana tabacum L.*) 50% concentration as a denture cleanser on the surface roughness of thermoplastic nylon

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Abstract

Microporosity of thermoplastic nylon can lead to increased surface roughness values. Surface roughness of thermoplastic nylon can facilitate colonization of microorganisms that can lead to denture stomatitis. The mechanical cleaning process of denture using an electric toothbrush and denture cleaning paste is considered effective for removing plaque and microorganisms attached. To reduce surface roughness, the use of natural materials such as tobacco leaves is considered beneficial because it can reduce the content of abrasive materials. This study aims to determine the effect of tobacco leaf paste as a denture cleanser on the surface roughness of thermoplastic nylon. This study using a laboratory experimental design with a post test only control group design involving 27 samples sized 60 x 10 x 2.5 mm which were divided into three groups including the brushing control group without paste, the brushing group with placebo paste, and the brushing group with 50% tobacco leaf paste (TLP). The results showed that tobacco leaf paste was considered effective as a thermoplastic nylon denture cleanser and had an effect on reducing surface roughness values with an average surface roughness value that was still acceptable to the oral cavity. In conclusion, 50% tobacco leaf paste is recommended as an effective denture cleanser and produces surface roughness values acceptable to the oral cavity.

Keywords: Tobacco Leaf Paste; Surface Roughness; Thermoplastic Nylon; Microporosity; Denture Cleanser.

1. Introduction

Dental and oral health are crucial aspects of overall health for every individual. The loss of some or all teeth can lead to disruptions in mastication function, Temporo Mandibular Joint (TMJ) function, and psychological well-being due to impacts on aesthetics and speech function [1]. One alternative for replacing lost teeth is the use of dentures. Dentures consist of components such as the artificial teeth, denture base, and connectors. The denture base is the component that directly contacts the soft tissues of the oral cavity and aims to restore tissue contours to their original function. Typically, denture bases are made from acrylic resin or thermoplastic nylon [2].

Thermoplastic nylon is a commonly chosen material for denture bases due to several advantages, such as having long-chain bonds that make it more stable and resistant to chemical solutions, high impact strength, and flexibility for comfortable use [3]. Additionally, thermoplastic nylon exhibits good aesthetics and biocompatibility while being hypoallergenic as it does not leave residual monomers [4]. However, this material also has disadvantages, including shrinkage, dimensional changes, and hydrophilicity, making it prone to water absorption [2].

The water-absorbing nature of thermoplastic nylon can lead to polymer chain disruption and causing surface roughness [4]. Surface roughness on thermoplastic nylon can facilitate the attachment of plaque and food residues to dentures. A rough surface on the denture base also provides a favorable environment for the colonization of microorganisms such

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as bacteria and fungi. The growth of bacteria and fungi on denture bases can contribute to various oral issues, including denture stomatitis [5].

Microorganism colonization on denture bases can be addressed and prevented through mechanical, chemical, or a combination of both cleaning methods. Mechanical denture cleaning involves brushing with a toothbrush using powder or cleansing paste. Chemical cleaning involves soaking dentures in a cleansing solution containing disinfectants, immersion in oxygenating agents, and microwave radiation. Chemical cleaning has a drawback: prolonged contact with the soaking solution can lead to absorption into micro-porosities, affecting the properties of thermoplastic nylon, such as increasing surface roughness [6]. Mechanical cleaning can minimize the absorption of cleansing agents as it requires less contact time, making it more effective for denture cleaning [7]. This can reduce the impact of cleansing agents on the properties of thermoplastic nylon.

The use of toothpaste as a cleansing agent is strongly discouraged due to the abrasive materials it contains, which can affect physical properties by increasing surface roughness beyond the tolerance level of the oral cavity [7]. Increased surface roughness can lead to microbial colonization and plaque accumulation. Therefore, an alternative material for denture cleansing paste with low abrasive materials is needed. One alternative is a herbal plant-based material combined with a soft-bristled toothbrush [6].

An affordable and readily available natural material is tobacco plant. Tobacco is a therapeutic herb widely distributed in Indonesia, particularly in Jember, East Java. While commonly used in the tobacco industry, it can serve other purposes, such as an alternative material for denture cleansing paste. Tobacco plants contain active compounds like alkaloids, flavonoids, steroids, and terpenoids with antibacterial and antifungal properties. Tobacco leaf extract has antibacterial effects, especially against *Streptococcus mutans* and *Porphyromonas gingivalis*, and antifungal effects against *Candida albicans*. The optimal concentration of tobacco extract as an antibacterial agent is 50%, considered most effective in inhibiting bacterial growth, including *Staphylococcus aureus* [8]. The brushing process using tobacco leaf (*Nicotiana tabacum L.*) paste for 23.5 minutes, equivalent to one year of brushing [9]. This study aimed to analyze the effect of 50% concentration tobacco leaf paste (*Nicotiana tabacum L.*) as a denture cleanser on the surface roughness of thermoplastic nylon compared to the acceptable surface roughness value in the oral cavity (0.2 µm) [10, 14].

2. Methods

This research is a laboratory experimental study with a randomized post-test-only control group design. The sample shape is a rectangular test plates with dimensions of 60 mm x 10 mm x 2.5 mm (ADA No. 12) [11]. The samples will be divided into three groups: Group 1, thermoplastic nylon plates brushed with an electric toothbrush without denture cleansing paste as the control group (9 samples); Group 2, thermoplastic nylon plates brushed with an electric toothbrush with a placebo paste (9 samples); and Group 3, thermoplastic nylon plates brushed with an electric toothbrush with 50% tobacco leaf paste (9 samples).

2.1. Tobacco Leaf Extraction

Kasturi tobacco leaves will be dried in an oven at 50°C, blended, and subjected to maceration using 96% ethanol for 72 hours. The solution will be filtered with filter paper, and the filtrate will be evaporated with a rotary evaporator for 1.5 hours at 60º C to obtain a concentrated extract.

2.2. Preparation of Tobacco Leaf Paste

The preparation of the placebo paste involves mixing all placebo ingredients, including calcium carbonate (29%), magnesium carbonate (26%), propylene glycol (8%), glycerin (6%), triethanolamine (TEA) (4%), distilled water (25%), and peppermint oil (2%) in a mortar and pestle until homogenous. The preparation of 50% tobacco leaf cleaning paste involves mixing 50 grams of the placebo paste with 50 grams of tobacco leaf extract and stirring until homogenous.

2.3. Manufacturing of Thermoplastic Nylon Plates

A master model is created with dimensions of 60 x 10 x 2.5 mm, totaling 27 pieces, and a sprue is made from red wax. The master model and sprue are placed in the mold space, subjected to the wax elimination process through boiling. The mold space is coated with a separator, and then melted thermoplastic nylon at 280ºC in a cartridge is injected into the mold. Pressure is applied using a hydraulic bench press at 6-8 bars for 5 minutes, followed by cooling [12].

2.4. Mechanical Cleaning with Denture Cleansing Paste

The polished surface is brushed with an electric toothbrush and distilled water for 23.5 minutes for the control group, using 3 mg of placebo paste for Group 2, and using 50% tobacco leaf paste for Group 3.

2.5. Surface Roughness Testing

The thermoplastic nylon plates are placed on a flat surface. Measurements are taken by placing the stylus at 3 different points. The Surface Roughness Tester is activated until the monitor displays the surface roughness value [13].

The obtained data will undergo normality testing using the Shapiro-Wilk test and homogeneity testing using Levene's test. If the data are normally distributed and homogenous ($p>0.05$), then further analysis will involve the parametric statistical test, One-Way ANOVA.

3. Result

The study on the effect of tobacco leaf paste as a denture cleanser on the surface roughness of thermoplastic nylon was divided with two sample groups: the control group and the treatment group. The control group in this study consisted of thermoplastic nylon plates brushed without using denture cleaning paste. The treatment group was divided into two subgroups: one subgroup with thermoplastic nylon plates brushed using a placebo paste and another subgroup with thermoplastic nylon plates brushed using 50% concentration tobacco leaf paste. Brushing was performed on the polished surface of the plates for 23.5 minutes for each sample in each treatment group, and measurements were taken once, immediately after brushing. The data on surface roughness values can be seen in Table 4.1.

Table 1 Surface roughness value of thermoplastic nylon after brushing

Sample groups	Control	Placebo paste	TLP 50%
1	0.173667	0.261667	0.039667
2	0.077333	0.182667	0.188000
3	0.067333	0.233333	0.196333
4	0.171667	0.160333	0.336333
5	0.285000	0.190000	0.168333
6	0.196667	0.121000	0.094667
7	0.292667	0.266667	0.139333
8	0.094667	0.219667	0.354333
9	0.145000	0.261000	0.336667
Average	0.167111	0.210704	0.205963
Standard deviation	0.082426	0.050806	0.113140

Based on Table 4.1, the highest average surface roughness value was found in the brushing with placebo paste group, which was 0.210704, followed by the brushing with 50% tobacco leaf paste group with a value of 0.205963. The control group, where brushing was performed without denture cleaning paste, showed a surface roughness value of 0.167111.

The average surface roughness values for thermoplastic nylon plates after the treatment, specifically brushing, are presented in the form of a bar chart in Figure 4.1.

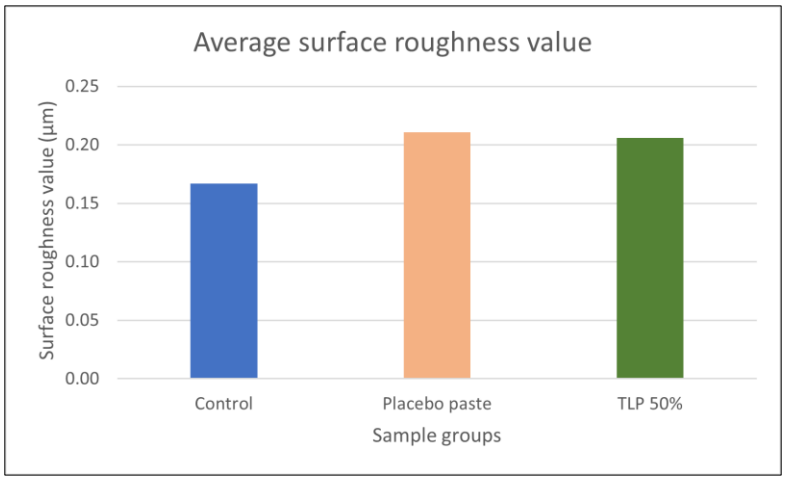

Figure 1 The average surface roughness value based on sample group (X-axis) and surface roughness value (µm) (Y-axis)

The data analysis in this study was conducted statistically to assess normality, homogeneity, and differences among treatment groups. The obtained research data underwent a normality test using the Shapiro-Wilk test. The normality test was performed to determine whether the obtained data followed a normal distribution. If the significance value (p) is greater than 0.05, the data are considered normally distributed; if p is less than 0.05, the data are considered not normally distributed. The results of the normality test can be seen in Table 4.2.

Table 2 Normality test results using the Shapiro-Wilk test

Sample groups	**Sig.**
Control	0.348
Placebo paste	0.441
TLP 50%	0.322

The homogeneity test was conducted using Levene's test. If the homogeneity test results in a significance value (p) greater than 0.05, the data are considered homogeneous; if p is less than 0.05, the data are considered not homogeneous. The results of the homogeneity test can be observed in Table 4.3.

Table 3 Homogenity test using Levene's Test

Levene's Test	**df1**	**df2**	**Sig.**
2.552	2	24	0.099

Based on the results of the normality test, the significance values for the control group, placebo group, and 50% tobacco leaf paste group were 0.348, 0.441, and 0.322, respectively. These significance values are > 0.05, indicating that the data are normally distributed. Regarding the homogeneity test, the significance value obtained was 0.099, which is also > 0.05. Therefore, it can be concluded that the data are homogeneous. Consequently, the data can proceed to the One-Way ANOVA test to determine if there is a significant difference between the independent and dependent variable groups. If the One-Way ANOVA test results in a significance value (p) greater than 0.05, there is no significant difference between the groups. Conversely, if p is less than 0.05, it indicates a significant difference. The results of the One-Way ANOVA test can be seen in Table 4.4.

Table 4 One Way ANOVA test result

Data	**Sig.**
Surface roughness	0.508

Based on the results of the One-Way ANOVA test in Table 4.4, the significance value (p) is greater than 0.05, specifically 0.508. Therefore, it can be concluded that there is no significant difference between the data of the independent and dependent variable groups.

4. Discussion

The surface roughness of materials used for dentures needs to be considered before use in the oral cavity. The surface roughness on the denture base is one of the impacts resulting from the mechanical cleaning of dentures, especially using brushing methods. Research by Abuzar (2010) states that the acceptable surface roughness value for thermoplastic nylon in the oral cavity is 0.2 μm [14]. In Table 4.1, both the control group and the treatment group show the presence of surface roughness. Based on the One-Way ANOVA test, it was also found that there was no significant difference between the variable groups. This can happen because of the nature of thermoplastic nylon itself, which easily absorbs liquids. The hydrophilic nature of thermoplastic nylon is caused by several factors such as sample size, sample microporosity, and the duration of contact between materials. All three factors can increase the surface roughness value of thermoplastic nylon [12]. The denture cleaning process using brushing does not require a long time to come into contact with the cleaning material. In this study, brushing was done for 23.5 minutes, assuming it represents the duration of denture brushing for 1 year [9]. This brushing time aims to minimize the absorption of the cleaning material into the microporosity of the plates, resulting in low surface roughness values.

The surface roughness in all treatment groups resulted in higher values than the control group. This is because of the abrasion process during brushing with an electric toothbrush and denture cleaning paste. Abrasion occurs due to the rotation of the electric toothbrush and the abrasive material contained in the cleaning paste between the toothbrush and the material surface. Toothpaste containing abrasive materials with hard particle structures can erode softer surfaces [15]. This can cause an increase in surface roughness on thermoplastic nylon plates. Additionally, surface roughness can be influenced by polishing and finishing techniques. Polishing techniques are influenced by various types of abrasive materials and the order of polishing techniques used. The particle size of the abrasive material will affect the level of polishing and the scratch pattern produced on the surface. Fine particles produce minimal surface abrasion even if the abrasive material is highly scaled, while coarse particles, which are the most abrasive, can leave large surface scratches, making the surface more likely to produce high surface roughness values [16].

Table 4.1 shows that the control group, brushing with a placebo paste, and brushing with 50% tobacco leaf paste treatment groups all exhibit different average surface roughness values. The highest average surface roughness value for thermoplastic nylon plates is found in the placebo paste brushing group, at 0.210704 μm. The average surface roughness value for the 50% tobacco leaf paste brushing group is 0.205963 μm. Based on these results, it can be seen that the 50% tobacco leaf paste has almost the same effect on surface roughness as the placebo paste. The lowest average surface roughness value for thermoplastic nylon plates is found in the control group brushed without paste, at 0.167111 μm. This value is lower than the average value in the treatment groups.

In the control group, the plates were brushed using an electric toothbrush and distilled water for 23.5 minutes. Although not brushed using a cleaning paste containing abrasive materials, the plates in the control group still show surface roughness values. In addition to the brushing process, surface roughness in the control group can be caused by several factors, one of which is an imperfect polishing process. This could happen because thermoplastic nylon has a low melting temperature, making it difficult to polish. Furthermore, slow cooling rates in thermoplastic nylon can result in rough plate surfaces [17]. The second factor is the hydrophilic nature of thermoplastic nylon, making it prone to absorbing water. This can cause polymer chain interruptions and increase surface roughness values [4].

The group brushed with a placebo paste is the group with the highest average surface roughness compared to other groups. This high surface roughness value is due to the high content of abrasive materials. In this study, abrasive materials such as calcium carbonate (29%) and magnesium carbonate (26%) were used in the placebo paste. Abrasive materials are crucial components of denture cleaning paste as they are needed to remove plaque, debris, and stains from dentures. However, the use of abrasive materials also leads to abrasive wear on the surface of thermoplastic nylon plates. This can occur because the hard particles in the abrasive material directly interact with the plate surface [7]. This abrasive wear is what causes the high surface roughness value of thermoplastic nylon plates brushed with a placebo paste.

The sample group brushed with 50% tobacco leaf paste has a surface roughness value of 0.205963 μm. This surface roughness value is lower compared to the sample group brushed with a placebo paste. This can occur because of the additional ingredient, tobacco leaf extract, reducing the content of abrasive materials compared to the placebo paste [18]. When compared to the control group, the surface roughness value in the group brushed with 50% tobacco leaf

paste still shows a higher number. However, brushing with 50% tobacco leaf paste has better antimicrobial properties compared to brushing without paste, as in the control group. Additionally, the surface roughness value in the group brushed with 50% tobacco leaf paste is still tolerable because it approaches the acceptable surface roughness value in the oral cavity. Therefore, brushing with 50% tobacco leaf paste is considered the most effective for use as a denture cleaning material.

The results of the parametric statistical analysis using One-Way ANOVA in Table 4.4 show that there is no significant difference between the control group and the treatment group. The lack of significant difference in all groups is due to the closely similar average surface roughness values between these groups. In the treatment groups, the placebo paste group and the 50% tobacco leaf paste group show insignificant differences in the results of the One-Way ANOVA test, but quantitatively, the surface roughness value in the 50% tobacco leaf paste group is lower. The addition of tobacco leaf extract to denture cleansing paste has been proven to affect the surface roughness values, resulting in a reduction in surface roughness due to the decreased abrasive content [18].

The surface roughness in the treatment group with 50% tobacco leaf paste is caused by several factors, such as the contact between thermoplastic nylon plates and the chemical compounds found in tobacco leaves, namely phenolic compounds. One of the active compounds in tobacco plants is flavonoids, which belong to the phenol group. Phenol present in tobacco leaves, when directly penetrating thermoplastic nylon plates, can cause chemical damage to the surface of thermoplastic nylon plates [19]. The (-OH) group on thermoplastic nylon tends to attract H+ ions present in phenol and allows the penetration of this acidic substance into the microporosity of thermoplastic nylon material [20]. The H+ ions will occupy positions between polymer chains, causing the polymer chains of thermoplastic nylon to break and detach. The abundance of Hydrogen ions (H+) can lower the surface tension, resulting in diffusion into the polymer chain of thermoplastic nylon and causing the polymer chain bonds to become unstable. This solubility leads to many empty spaces in the polymer matrix, making it easier for bonds to form between the acidic components and the polymer matrix [19]. As a result, the disrupted and separated polymer chains can increase the surface roughness of thermoplastic nylon plates.

5. Conclusion

Based on the results of research that has been done, it can be concluded that tobacco leaf paste (*Nicotiana tabacum L.*) 50% concentration has an effect as an denture base cleanser on thermoplastic nylon surface roughness because it produces a surface roughness value acceptable to the oral cavity (0.2 μm).

Compliance with ethical standards

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Disclosure of Conflict of interest

The authors declare that there is no conflict of interest regarding the publication of this article.

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