Effects Of 25%, 37.5% and 50% *Musa Acuminata* Extract as a Denture Cleanser on the Flexural Strength and Surface Roughness of Acrylic Resin

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Abstract. Mauli banana (*Musa acuminata*) stem extract contains potential bioactive compounds against Streptococcus mutans and Candida albicans in which can be used as an alternative for synthetic denture cleanser. The use of denture cleanser may weaken flexural strength and surface roughness of heat-cured acrylic resin. This study was subjected to analyse the effect of 25%, 37.5% and 50% Mauli bananas stem extract immersion as a denture cleanser to surface roughness and flexural strength of heat-cured acrylic resin. Seventy specimens of heat-cured acrylic resin were fabricated in rectangular shape with 65 mm x 10mm x 3.3 mm in size according to ISO standard 1567. Treatment groups comprised of Mauli banana stem extract at the concentration of 25%, 37.5%, 50% while 0.2% Chlorhexidine gluconate (CHX) and aquadest were used as control groups. Heat-cured acrylic resin immersion was performed for 5 days. Thirty-five specimens were tested for flexural strength using universal testing machine and other 35 specimen were tested for surface roughness using surface roughness tester SJ-30. Analyzing results with one-way ANOVA test, no significant differences (p=0.986) of surface roughness was obtained from Mauli banana extract of 25% (0.158±0.020 μm), 37.5% (0.160±0.030 μm) and 50% (0.162±0.037 μm), 0.2% CHX (0.155±0.020 μm), aquadest (0.157±0.022 μm). The result flexural strength was significantly differed between 0.2% CHX (79.05±3.10MPa) and aquadest (94.36±6.31MPa) (p=0.003) with no significant differences (p>0.05) between Mauli banana stem extract concentration group 25% (85.30±8.65MPa), 37.5% (84.91±6.60MPa) and 50% (83.60±8.36MPa). No effects of 25%, 37.5% and 50% mauli banana stem extract immersion was presented upon flexural strength and surface roughness of heat-cured acrylic resin therefore it can be used as an alternative for denture cleanser material.

Keywords: *Musa acuminata*, denture cleanser, flexural strength, surface roughness, heat-cured acrylic resin

1. Introduction
Oral and denture hygiene illustrate direct effect upon the health of oral tissues, teeth and the associate denture [1]. Based on Basic Health Research (RISKESDAS) 2007, the percentage of fixed denture and removable denture users in Indonesia is 4.5% [2]. South Borneo is reported with a number of 3.3% population with removable denture ranging from 0.6% - 10.8% [3]. Denture hygiene should be maintained so that plaque on denture base may not accumulate and may not promote the growth of...
Candida albicans as the cause of oral disease such as candidiasis or denture stomatitis [1,3]. Chemically-formulated denture cleansers are generally employed by denture wearers to clean the denture [4]. One of the most common denture cleansers used is 0.2% CHX. Notwithstanding fungicidal and broad-spectrum bactericidal effect of CHX, numerous side effects may arise due to chemical ingredients in 0.2% CHX. Discomfort, hypersensitivity reaction and discoloration of the teeth may be experienced by CHX customers. Prolonged usage may also indicate a loss of taste [4]. Denture cleaner solution contact with denture base may cause changes in physical and mechanical properties of acrylic resins such as changes in color stability, an increase in surface roughness and a reduction in flexural strength of acrylic resin [5].

Adverse effects of chemically-formulated drugs are the main reason in continuing traditional medicines development for alternative substitute [6]. Mauli banana plant is one of medicinal plants originated from South Kalimantan which may advance as an alternative for chemical medicine. Apriasari et al (2015) research mentioned that the compounds in Mauli banana stem extract acquire antioxidant, antibacterial, antifungal and non-toxic properties to the cell [7]. Mauli Banana stem extract with dosages between 125-1000 mg / kg BW are proved to have non-toxic effect to the liver of mice [6]. Other studies have also displayed no toxicity of 25% extract concentration to BHK 21 fibroblasts [8]. Mauli banana stem extract at concentration of 37.5 % and 50% moreover exhibit immunomodulatory effect [9]. Research by Septianoor et al (2013) revealed that Mauli banana extract with concentrations of 6.25%, 12.5% and 25% has antifungal capability against Candida albicans. The ability of Mauli banana stem extract to inhibit and kills microorganism especially Candida albicans on (60-100%) denture users assist the reliance of Mauli banana stem extract utilization as a denture cleanser [6].

Despite of Mauli banana stem extract predilection as an alternative for denture cleanser, no research has been conducted to elaborate its constitution. Several types of classes of phenol compounds might be discovered in Mauli banana stem extract such as saponins, tannins and flavonoids. These compounds hold antiseptic property which enable the inhibition of bacterial growth and further eliminate respective microorganism [7]. Based on a research by Wulandari (2012), surface roughness on acrylic resin might be exerted by the contact with phenolic compounds [10]. Extensive elaboration in the use of Mauli banana stem extract as denture cleanser is unable to attain by merely analyzing its effect on surface roughness and flexural strength of heat-cured acrylic resin.

Ideally, no side effect should be emerged toward the properties of denture base material following disinfection methods [11]. Various advantages of heat-cured acrylic resin forged this resin as one of high demand material for artificial denture bases manufacture [12]. It is able to absorb water through a diffusion reaction [13]. Phenols contact on acrylic resin surface will promote diffusion and chemical destruction through hydrolysis reaction. This condition leads into the degradation of polymer matrix creating roughness on the surface of acrylic resin [14]. Surface roughness in denture is a crucial aspect owing to its potential in resisting the growth of plaque which determines the quality and duration of denture use [15]. Flexural strength describes the resistance of denture base over chewing load as one of several aspect encompassing heat-cured acrylic resin mechanical properties. Many factors may affect flexural strength of acrylic resins, one of those is water absorption [10]. Immersion in denture cleansing solution may cause changes in flexural strength of the acrylic resin due to its absorbing ability as denture base material [11]. An in-vitro study of five days immersion of acrylic resin denture shows comparable result with one-year actual condition simulation that denture user experienced [16].

The use of Mauli banana as a denture cleanser is expected not to affect the roughness of heat-cured acrylic resin surface. Based on above backgrounds, it is necessary to identify the effect of heat-cured acrylic resin immersion in Mauli banana stem extract 25%, 37.5% and 50% as denture cleanser solution on the surface roughness and flexural strength of acrylic resin. The result of this study is anticipated to be a reference for the use of Mauli banana stem extract as an alternative natural denture cleanser solution.
2. Materials and Methods

2.1. Specimens preparations
The research had passed ethical clearance issued by the Ethics Committee of Faculty of Dentistry, University Lambung Mangkurat no. 017/KEPKG/FGKULM/EC/VIII/2017. Seventy specimens of heat cured acrylic resin were fabricated according to the manufacturer’s instructions using conventional flasking and pressure-pack technique. Heat-cured acrylic resin was packed in the flask in a rectangular shaped with length of 65mm, width of 10mm and thickness of 3.3mm according to International Organization for Standardization (ISO): 1567. Polymerization of the resin was conducted in boiling water for 45 minutes, subsequently the curing flask were cooled to room temperature and the specimens were deflasked. The surfaces were finished and polished using 1000-, 2000- grit sandpaper. The dimension of specimens was checked with a digital caliper, subsequently specimens were stored and incubated in saline solution at 37°C for 24 h before immersion process.

2.2. Immersion process
Seventy specimens of acrylic resin (n=7/group) were prepared and distributed into three treatment groups and two control group, Mauli banana stem extract solution at the concentration 25%; Mauli banana stem extract solution at the concentration 37.5%; 0.2% CHX solution as positive control and aquadest solution as negative control group for 5 days to represent a 20 minute simulation of the use of denture cleanser solution for 1 year.

2.3. Measurement of flexural strength value
The flexural strengths were measured using Universal Testing Machine with 3-point-bending technique, load 50 kgf was applied vertically with cross head speed of 5mm/min, until fracture. Thirty-five specimens were measured and maximum load value was recorded to calculate the flexural strength value. The calculation of flexural strength is determined using the formula of:

\[ S = \frac{3PL}{2bd^2} \]

Abbreviation:
S: flexural strength (MPa = kg / mm2)
P: fracture force or load (N) or (kgf)
L: length / width specimens spacing (cm)
b: specimen width (cm)
d: thickness of test plate (cm)

2.4. The measurement of surface roughness value
Surface roughness were measured using profilometer Surface Roughness Tester SJ-301 on another thirty-five specimens (n=7/group). The specimen was placed on a flat plane and the stylus tip was set on the surface of the specimen. The tool was activated and the stylus tip will move along a straight line (horizontally) along the surface and back again under constant pressure. Three measurements were conducted for each specimen, the average of three reading was considered as the final Ra value for the specimen. Data result was processed by using a computer software.

3. Results and Discussion

3.1. Flexural strength test
The mean value of the flexural strength of acrylic resin in Mauli banana extract immersion group was higher than 0.2% CHX (79.05±3.10MPa) and lower than Aquadest group (94.36±6.31 MPa). The flexural strength test of acrylic resin in Mauli banana extract immersion group showed the highest value at 25% concentration (85.30±8.65MPa) and the lowest value at 50% concentration (83.60±8.36MPa). There were no significant differences (p>0.05) among Mauli banana stem extract concentration group 25% (85.30±8.65); 37.5% (84.91±6.60 MPa) and 50% (83.60±8.36 MPa), but significantly differed between 0.2% CHX (79.05 ± 3.10 MPa) with Aquadest (94.36±6.31 MPa) (p=0.003) (Table 1).
Table 1. Mean value and standard deviation of all groups.

| Group                             | Flexural Strength (MPa) | P    |
|-----------------------------------|-------------------------|------|
| 0.2% CHX                         | 79.05 ± 3.10<sup>A</sup> | 0.005|
| Aquadest                         | 94.36 ± 6.31<sup>B</sup> |      |
| 25% Mauli Banana Extract         | 85.30 ± 8.65<sup>AB</sup>|      |
| 37.5% Mauli Banana Extract       | 84.91 ± 6.60<sup>AB</sup>|      |
| 50% Mauli Banana Extract         | 83.60 ± 8.36<sup>AB</sup>|      |

One-way ANOVA test and post Hoc Bonferroni

*Value with different superscript letters shows significant difference at p < 0.05

The results of the study showed there was significant difference between the flexural strength value of acrylic resin immersed in aquadest compared with 0.2% CHX group. The research from Carvalho (2013), Oyar (2014) and Bhat (2015) mention that immersion of acrylic resin in CHX solution showed no altered in the flexural strength value of acrylic resin [17,18,19]. This result difference occurred in the study depends on the type and length of contact, in our study the flexural strength of acrylic resin was evaluated after long-term immersion in denture cleanser, longer immersion in denture cleanser may cause structural changes in the inner matrix of the polymer [4,20]. Use of denture cleansers such as 0.2% CHX is known may affect the properties of acrylic resins if it used for a long time [21]. Meanwhile, in our study, aquadest does not altered flexural strength which is in line with the study of Wulandari et al, 2012 stated immersion of acrylic resin in Aquadest solution for 4 days, 12 days and 19 days not altered in the flexural strength [10]. Aquadest does not contain active ingredients that may destroy acrylic structure. Therefore, no significant changes on the properties of the acrylic resin shall be observed [14].

Chlorhexidine is a bisbiguanide compound with symmetrical molecules of 2 chlorophenyl rings and 2 biguanides chains linked to hexamethylene chain [22]. This compound is a soluble strong base [12]. Solution of CHX as a denture cleanser has a high ionic concentration which may dissolve the residual monomer of acrylic resin in a denture cleanser solution. This reaction will promote the acrylic resin to compensate and shrinkage [18]. Compounds of CHX that acts as an antimicrobial agent may have a contact with the acrylic resin and able to diffuse into the polymer bond through the gap on the surface of the acrylic resin. The compounds may disrupt the bonding of the polymethyl-methacrylate chain and subsequently degradation occurred in the polymer bonds resulting in reduction of the acrylic resin flexural strength [21].

In our study, Mauli banana stem extract showed not altered flexural strength compared to aquadest. Mauli banana stem extract contains of tannin, saponin and flavonoid compounds that potentially fight against Candida albicans [7]. Saponin is an active compound which occupies 14.49% of total compounds in Mauli banana stem extract [23]. It has glycosyl groups as polar groups and triterpenoids as non-polar groups that are active on its surface. This polar-non polar groups will form a foam such as soap if contact with water and also act not only as a detergent but also as a denture cleanser by releasing CO2 [23,24,25]. The release of CO2 result in oxidation reaction that may disrupt electron conjugation of polymethyl-methacrylate bond chain and subsequently change the chemical structure of acrylic resin [16]. This small amount of saponin content allegedly not provide significant effect on the flexural strength. This is in line with the research of Khalaf et al, 2013 which shows that immersion of acrylic resin in Siwak solution containing saponin content does not show significant effect on the flexural strength [26,27].

Flavonoids are acidic polyphenol compounds which may react with ester compounds of polymethyl-methacrylate in acrylic resin. Flavonoids contains of 0.25% in a total of mauli banana stem extract. Acid contacted with acrylic resin may cause the surface of acrylic resin to become weak and easily soluble, this may create a porous on the surface of denture and facilitates phenol compounds to penetrate on the
acrylic resin, subsequently hydrolysis reactions occurred and interfere with acrylic resin polymer chain bonds. This reaction may result in reduction of the acrylic resin flexural strength. Mauli banana stem extract has only a small number of flavonoids, therefore not significantly affect on the flexural strength of acrylic resins [23,27]. Tannin is the highest compound (67.59%) identified in Mauli banana stem extract. It contains of acidic polyphenols, but classified as a weak acid therefore does not have a significant effect on the acrylic resin polymer bonds refer to flexural strength and surface roughness [23,28].

3.2. Surface roughness test
We found that the highest mean value for Surface roughness of heat-cured acrylic resin specimens were immersed in Mauli banana stem extract with concentration of 50% (0.162 ± 0.027μm) while the lowest mean value was immersed in aquadest solution (0.155 ± 0.0207μm). One way ANOVA test result with significance value of 0.986 (p>0.05) which mean there was no significant difference of surface roughness value of Mauli banana extract of 25% (0.158 ± 0.020 μm), 37.5% (0.160± 0.030 μm) and 50% (0.162 ± 0.0027 μm), 0.2% CHX (0.157 ± 0.022 μm) also Aquadest (0.155±0.020 μm) (Table 2).

| Group                      | Surface Roughness (μm) | P     |
|---------------------------|------------------------|-------|
| 0.2% CHX                  | 0.155±0.020            |       |
| Aquadest                  | 0.157±0.022            | 0.986 |
| 25% Mauli Banana Extract  | 0.158 ± 0.020          |       |
| 37.5% Mauli Banana Extract| 0.160± 0.030           |       |
| 50% Mauli Banana Extract  | 0.162 ± 0.037          |       |

One-way ANOVA test

The results of the study showed the value of surface roughness after immersion in 0.2% CHX (0.15±0.02μm) for 5 days was no significant difference to aquadest immersion. Our result was in line with previous studies that show there is no significant effect on the surface roughness of heat-cured acrylic resin by immersion in 0.2% CHX solution even with longer immersion times and even with a slight increase in concentration [29]. Azevedo, 2006 proved an increase in the surface roughness of acrylic resin, but not significant on heat-cured acrylic resins with a 7-day immersion in 4% CHX solution [30].

Surface roughness value after immersion in the aquadest solution for 5 days has the lowest surface roughness value compared to other immersion groups even statistically no difference. Notwithstanding aquadest show the lowest, it has a role in the degradation which is initiated by penetration and absorption of water molecules into intermolecular chains of acrylic resin and result in decreased polar interactions [31]. Heat-cured acrylic resin material has a long polyester repeating bond form with a methyl methacrylate unit. The reaction leads to create the distance between polymer that causes the expansion of the matrix and separate the polymer chain bonds on the surface. A study by Sundari et al, 2016 proves that there is a role of water in the hydrolytic degradation reaction of heat-cured acrylic resin material. The penetration depth level of molecules into micro porosity is influenced by the duration of immersion. This molecule may fill the place between the polymer chains therefore the chemical bond structure could be disrupted and microporosity increase in surface roughness [12,32].

Measurements of surface roughness dental material require appropriate parameters as reference. According to Hilgenberg (2008) clinically the ideal dental material has a surface roughness level of ≤ 0.2 μm after polishing. This parameter is commonly used in previous research therefore the comparison
of research results can be more suitable [33]. Based on the parameters, our study shows the value of surface roughness under ideal condition.

The ideal denture cleanser requires no negative effect or damage on the denture material. The compounds such as tannins, saponins, flavonoids contained in the mauli banana stem extract solution react with acrylic resin for five days of immersion did not have a significant effect on the surface roughness and flexural strength, therefore mauli banana stem extract with concentration of 25%, 37.5% and 50% has fulfilled the requirements as a denture cleanser solution in terms of surface roughness and flexural strength.

4. Conclusion
There were no effects of 25%, 37.5% and 50% Mauli banana stem extract immersion to the flexural strength and surface roughness of heat-cured acrylic resin therefore it can be used as an alternative to denture cleanser material.

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