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The Effect of Acid Types in Cuka Pempek on The Surface Roughness of Acrylic Resin Denture Base

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Abstract

Introduction: Cuka pempek is a typical Palembang food that contains acid as one of its ingredients. Continuous consumption of cuka pempek can affect the surface roughness of hot polymerized acrylic resin denture bases due to its ability to absorb liquids. **Purpose:** To determine the effect of acid types in cuka pempek on the surface roughness of hot polymerized acrylic resin denture bases. **Methods:** Thirty plates of hot polymerized acrylic resin measuring 65mm x 10mm x 2,5mm were divided into 3 groups. The initial surface roughness value (pretest) was calculated using a surface roughness tester. Soaking was carried out on group I (tamarind-based cuka pempek), group II (vinegar acid-based cuka pempek), and group III (control) with distilled water. Soaking was carried out for 30 hours in an incubator at 37°C. Measurement of the final surface roughness (post-test) was carried out. **Results:** The results of the normality test with the Shapiro-Wilk and the Levene test homogeneity test showed that the data were found to be normally distributed and homogenous. The paired t-test showed significant differences in all groups. The results of the one-way ANOVA test showed a significant difference. The results of the Bonferroni post hoc test showed a significant difference between tamarind-based and vinegar acid-based cuka pempek against distilled water, while there was no significant difference between tamarind-based and vinegar acid-based cuka pempek. **Conclusion:** There is an effect of the type of acid in cuka pempek on the surface roughness of the hot polymerized acrylic resin denture base.

Keywords: *Cuka pempek*; heat-polymerized acrylic resin; surface roughness

Introduction

Dentures are a solution to improve aesthetics, speech ability, occlusion, chewing function, and maintain oral health in individuals with an edentulous condition.[1] The base is a part of the denture typically made of hot-polymerized acrylic resin. This material is often used because it is affordable, easy to apply and polish, and has good aesthetics. However, one of its drawbacks is that it easily absorbs water.[2,3]

The material's capacity to absorb water becomes particularly concerning when exposed to acidic food or beverages. In such conditions, water molecules can penetrate the polymethyl methacrylate chain and infiltrate the intermolecular spaces within the polymer chains, leading to chain separation. This disruption contributes to the formation of porosities, increasing the surface roughness.[4] This phenomenon was demonstrated in a study by Sofya et al., in which heat-polymerized acrylic resin immersed in *keueng masam* sauce for two days exhibited a significant increase in surface roughness ($p < 0.05$) compared to the pre-immersion condition.[3]

Clinically, the surface roughness of acrylic resin should remain below 0.2 µm, as values exceeding this threshold can promote bacterial colonization, plaque accumulation, and increased adhesion of *Candida albicans*.[1,3] Uncontrolled *Candida albicans* in the oral cavity may lead to fungal infections in the mouth, such as oral candidiasis (oral thrush), and contribute to the development of denture stomatitis, posing a health risk to denture wearers.[1,5] One example of an acidic food commonly consumed that may contribute to this issue is cuka pempek, .

Cuka pempek is a traditional sauce served with pempek, a well-known dish originating from Palembang, and is widely consumed daily by individuals across all age groups. The preparation of cuka pempek requires ingredients such as sugar, chili, garlic, salt, and optionally shrimp, with the addition of acidic components like tamarind or vinegar. The type of acid has a strong influence on the pH level of the sauce, as demonstrated by Dewi et al. Cuka pempek made with tamarind had a lower pH than vinegar, 4.2 and 4.7, respectively.[6] This variation in acidity may affect the surface roughness of acrylic denture base when exposed to the sauce. Therefore, it is clinically relevant to identify the type of acid that minimizes changes in the surface roughness of acrylic resin. Based on this rationale, the present study aims to investigate the effect of cuka pempek made with tamarind versus vinegar on the surface roughness of heat-polymerized acrylic resin.

Methods

This study is an analytical quasi-experimental research, using a pretest-posttest control group design. A total of 30 heat-polymerized acrylic resin specimens were prepared, each measuring 65 mm x 10 mm x 2,5 mm following ADA Specification No. 12 (1974). All specimens included must have a flat, smooth, non-porous surface.[6] Each specimen was labeled and marked with three designated measurement points on its surface. The samples were divided into 3 groups: Group I was immersed in tamarind-based cuka pempek, Group II in vinegar-based cuka pempek, and Group III (control) in distilled water.

The cuka pempek used in this study was prepared fresh. Both tamarind and vinegar-based contained 20% acid content. To ensure accuracy and consistency in formulation, all ingredients were converted into grams (g) and milliliters (mL). For reference, 1 tablespoon of granulated sugar equals 15 g, 1 teaspoon of salt equals 5 g, and 1 tablespoon of vinegar corresponds to 15 mL. The ingredients of cuka pempek are presented in Table 1.[8]

Table 1. Cuka pempek ingredients[8]

Group 1		Group 2	
Water	750 ml	Water	750 ml
Palm sugar shell	500 gr	Palm sugar shell	500 gr
Garlic	75 gr	Garlic	75 gr
Green chili pepper	125 gr	Green chili pepper	125 gr
Sugar	200 gr	Sugar	200 gr
Fine salt	20 gr	Fine salt	20 gr
Tamarind	60 gr	cuka	60 ml

The pH of each solution was measured with a pH meter, Hanna HI98107 digital. A total of 5 samples were immersed in a petri dish filled with 25 ml of solution (Figure 1) for 30 hours in an incubator at 37°C.[6] The specimens were rinsed with water and dried using tissue by wiping the surface slowly, then measured using a surface roughness tester.

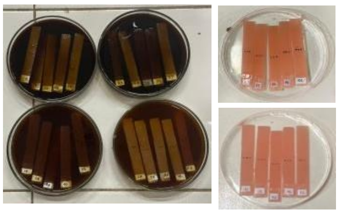

Figure 1. Immersion of samples in each solution

Acrylic resin surface roughness measurements were performed before and after immersion using a surface roughness tester with an accuracy level of 0,01 μm to 1 mm. The samples were placed on a flat surface to stabilize them with the polished surface facing the stylus. The stylus was positioned at the first measurement point and moved back and forth at a speed of 0,5 mm/second along the sample surface; the measurement data was displayed on the surface roughness tester monitor (Figure 2).[9] Measurements were then repeated at the next two additional points, then the average of the measurement results at the 3 points was calculated and the results were recorded for further analysis.

Figure 2. Sample measurement using a surface roughness tester

Results

The results of pH measurements in each solution group were obtained from a digital pH meter (Hanna HI98107) (Table 2).

Table 2. The pH value of each solution group

Group	pH
I (tamarind-based cuka pempek)	4,1
II (vinegar acid-based cuka pempek)	3,8
III (distilled water)	7,0

The highest mean surface roughness value of heat-polymerized acrylic resin plates was observed in group II, which used vinegar acid-based cuka pempek (0,1570 µm), while the lowest was found in group III, which used distilled water (0,0880µm). (Table 3).

Table 3. Average value of surface roughness of samples

Group	N	Surface Roughness (µm) Average ± SD	
		Pre	***Post***
I (tamarind-based cuka pempek)	10	0.0870±0,02214	0,1260±0,02221
II (vinegar acid-based cuka pempek)	10	0,0870±0,01252	0,1570±0,01889
III (distilled water)	10	0,0740.02066	0.0880±0,01989

The data were first analyzed for normality using the Shapiro-Wilk test and for homogeneity using Levene's test. Both tests indicated that the data were normally distributed and homogeneous ($p > 0.05$). Subsequent analysis using the paired t-test test, revealed a value of $p < 0.05$, which means that there is a significant difference in the surface roughness of hot polymerized acrylic resin before and after soaking (Table 4).

Table 4. Paired t-test results

Paired Samples Test								
	Paired Differences							
Pre-post	Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference		*t*	*df*	*Sig. (2-tailed)*
				Lower	Upper			
I (tamarind-based cuka pempek)	-,03900	,00568	,00180	-,04306	-,03494	-21,726	9	,000
II (vinegar acid-based Cuka pempek)	-,07000	,01155	,00365	-,07826	-,06174	-19,170	9	,000
III (distilled water)	-,01400	,00516	,00163	-,01769	-,01031	-8,573	9	,000

Furthermore, one-way ANOVA demonstrated a significant difference in surface roughness across all immersion groups ($p < 0.05$). (Table 5)

Table 5. One-way ANOVA test results

ANOVA					
Roughness					
	Sum of Squares	*df*	*Mean Square*	*F*	*Sig.*
Between Groups	.017	2	.009	9.055	.000
Within Groups	.054	57	.001		
Total	.071	59			

The Bonferroni post hoc test revealed a statistically significant difference in surface roughness between Group I and II compared to Group III (p < 0,05). However, no significant difference was found between Group I and Group II, with a p-value of 0,350 (p>0,05) (Table 6).

Table 6. Bonferroni post hoc test

Group	I (tamarind-based cuka pempek)	II (vinegar acid-based cuka pempek)	III (distilled water)
I (tamarind-based cuka pempek)		.350	.034*
II (vinegar acid-based cuka pempek)	.350		.000*
III (distilled water)	.034*	.000*	

*) Significant difference (p>0.05)

Discussion

This study found a difference in the surface roughness of heat-polymerized acrylic resin before and after immersion in Group I (tamarind-based cuka pempek), Group II (vinegar-based cuka pempek), and Group III (control). It can be attributed to the chemical composition of heat-polymerized acrylic resin, which is primarily composed of polymethyl methacrylate (PMMA). This monomer contains polar ester groups (-COOH), which have a strong tendency to absorb liquids. Water molecules can penetrate the polymer matrix and occupy the intermolecular spaces between the polymer chains. This leads to chain separation, porosity, and ultimately the increase in surface roughness.[4]

The highest mean surface roughness of acrylic resin was observed in group II (vinegar-based cuka pempek), with the value of 0,1570. This result may be related to the presence of acetic acid in vinegar. The hydronium ions [H3O]+ from the acid react with the ester groups in the acrylic resin, leading to degradation of the polymer bond and the formation of surface porosities.[2] During the polymerization reaction, methyl methacrylate monomer forms a polymer matrix with glycol dimethacrylate. This matrix is susceptible to degradation by water absorption and an excess of H+ ions from acid. The high concentration of H+ ions contained in the cuka pempek infiltrates the ester groups (COOH), destabilizing the intermolecular bonds, and altering the chemical structure. Esters are particularly prone to acid hydrolysis, which can result in the formation of microcracks and irregularities on the resin surface, thereby increasing surface roughness.[5]

Group I (tamarind-based cuka pempek) showed the second highest surface roughness after the vinegar-based group, with an average of 0,1260µm. Tamarind contains citric acid, which can increase the concentration of hydrogen ions (H^+), thereby lowering the pH of the solution. This is consistent with findings by Astiningsih et al., who examined the effect of turmeric-tamarind beverage on the surface roughness of conventional glass ionomer cement. Their study concluded that the lower the pH value and prolonged the exposure time, the more the diffusion of H^+ ions into the cement material, leading to the release of metal ions, which triggers dissolution and degradation of the material. As a result, there is an increase in porosity on the surface of conventional glass ionomer cement.[10]

In contrast, Group III (control), which was immersed in distilled water, had the lowest roughness value (0,0880). This finding aligns with the study by Puspitasari et al., which reported that the surface roughness of heat-cured acrylic resin was lower when immersed in distilled water compared to alkaline peroxide and celery extract for 5 days.[11] Distilled water is chemically pure and does not contain other ionic elements or active substances that could interfere with the polymeric structure of acrylic resin. Its neutral pH also minimizes the risk of polymer chain degradation, thereby preserving the material's surface integrity.[11,12,13]

The lower pH in the vinegar-based group may be related to the presence of acetic acid as its main component, which has stronger acidic properties and reduces the pH more drastically than tartaric acid, the main component in tamarind. Acetic acid has a dissociation constant (Ka) of $1,75 \times 10^{-5}$, while tartaric acid undergoes two stages of ionization. The first ionization in tartaric acid has a Ka of $9,04 \times 10^{-4}$, and a lower Ka for the second ionization. This two-stage ionization process results in fewer H^+ ions in tartaric acid solutions compared to acetic acid, thereby producing a higher. Meanwhile, distilled water in Group III maintains a neutral pH as it is free from ionic and acidic components.[14,15]

In this study, the group immersed in vinegar-based cuka pempek containing acetic acid exhibited the highest surface roughness. These findings support the conclusion that lower pH levels contribute to increased surface roughness of heat-polymerized acrylic resin. This trend aligns with the results reported by Sari et al., who examined the effect of cinnamon extract concentration on the surface roughness of heat-cured acrylic resin. Their study showed that as the cinnamon extract concentration increased, the pH decreased, with the highest surface roughness was observed at the lowest pH.[16]

In this study, the surface roughness of heat-polymerized acrylic resin increased after immersion; however, the average roughness remained below the clinical threshold of 0.2 µm (Table 3). Surface roughness values exceeding 0.2 µm have been associated with a higher risk of bacterial colonization, plaque accumulation, and *Candida albicans* adhesion.[1,3] These results suggest that cuka pempek made from tamarind or vinegar acid does not cause clinically significant surface degradation and may still be considered safe for consumption by denture wearers, particularly within one year. Nevertheless, denture users must maintain good oral and prosthetic hygiene to preserve denture longevity. This includes cleaning the denture thoroughly after breakfast and before bedtime for 2–3 minutes using toothpaste, rinsing with water after meals, and drinking water—especially after consuming acidic foods such as cuka pempek—to help neutralize oral pH and reduce surface wear.[17,18]

Conclusion

In conclusion, the type of acid used in cuka pempek significantly affects the surface roughness of heat-polymerized acrylic resin denture base materials.

Suggestion

It is expected that further research can be conducted on the surface roughness of denture bases with other types of acids. The results of the study are expected to be used as a source for further research using other denture base materials such as thermoplastic nylon and cobalt-chromium alloy.

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