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FLEXURAL STRENGTH OF HEAT-POLYMERIZED ACRYLIC RESIN AFTER ISOTONIC DRINK IMMERSION

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ABSTRACT

Hot polymerized acrylic resin is the most commonly used denture base material because it has good aesthetics and is economical. However, acrylic resin has low flexural strength so it is easily broken if dropped. One factor that affects flexural strength is the food and drink consumed. Consuming acidic drinks continuously for a long period can cause a decrease in quality. One of these drinks is isotonic drinks. Isotonic drinks have a pH between 2.4 and 4.5. This content has a high solubility level, which causes the denture base to weaken in withstanding chewing loads and breaks. This study aimed to determine the effect of isotonic drinks on the flexural strength of hot polymerized acrylic resin. This study is an experimental laboratory study with twelve acrylic samples (64 × 10 × 3.3 mm) were prepared according to ISO 20795-1:2013 and divided into two groups (n = 6): one immersed in aquabidest (control) and one in an isotonic drink (pocari Sweat) for 5 days. These results the mean flexural strength of the control group was 138.83 ± 6.39 MPa, while that of the isotonic group was 126.89 ± 9.36 MPa, with a significant difference (p = 0.027). Immersion in isotonic drinks significantly reduced the flexural strength of hot polymerized acrylic resin denture bases

Keywords: *Hot polymerization acrylic resin, isotonic drinks, flexural strength*

INTRODUCTION

Health is an element of society that is an important part of everyday life. Not only general health needs to be considered, but dental and oral health also need to be considered. (1) According to data from the World Health Organization (WHO) in the World Dental Health Report, 90% of the Indonesian population experiences dental and oral diseases. (2) Problems that are often found in dental and oral health, one of which is tooth loss. Based on the results of data from the Basic Health Research (RISKESDAS) of the Ministry of Health of the Republic of Indonesia in 2018 regarding the characteristics of age groups, it shows that the rate of tooth loss at the age of 35-44 years is 17.5%, then at the age of 65 years and over by 30.6%. (3) As age increases, tooth loss increases, requiring the use of dentures.

Dentures, also known as false teeth, are prostheses that can replace missing teeth to improve chewing function, phonetics, aesthetics, maintain soft tissue health, and prevent damage in the oral cavity. (4) In general, there are two types of dentures, namely fixed dentures and removable dentures. Fixed dentures are dentures that replace all missing natural teeth and gum tissue, while removable dentures are dentures that replace only part of missing natural teeth and can be removed and replaced by the patient. (4) The process of caring for and making removable dentures is more practical, the price is affordable for patients who have lost teeth, so that removable dentures are often in demand by patients. (5) Removable dentures are classified into two, namely complete removable dentures (RTDs) and partial removable dentures (RPDs). (6) One component of a partial removable denture (RPD) is its base. (7).

The base of a removable partial denture is the part of the prosthesis that faces the soft tissues of the mouth, which functions to improve the contour and tissue as a place for the denture elements.(8) Since 1938, Polymethyl methacrylate (PMMA), better known as acrylic resin, has become the most important denture base polymer used in dentistry to date. (9) Based on the International Organization for Standardization (ISO) 20795-1 in 2013, acrylic resin has five types, namely heat polymerization acrylic resin, self-polymerization acrylic resin, light polymerization acrylic resin, microwave polymerization acrylic resin, and thermoplastic. Meanwhile, according to the American Dental Association (ADA), there are

two types of acrylic resin: heat polymerization and self-polymerization.(10). The type of acrylic resin that is most often used is heat polymerization acrylic resin because it has good biocompatibility properties, satisfactory aesthetic appearance, is non-toxic, does not dissolve in oral fluids, does not cause irritation, is easy to repair, and is economical. However, heat polymerization acrylic resin also has weaknesses, namely its mechanical properties, which are easily cracked or broken. (11). Cracked dentures can be caused by long-term use and the strength of the base material itself in supporting the load, so that continuous chewing pressure can cause damage to the base of the denture.

Flexural strength is essential to influence the strength of the denture base in resisting fracture. (12) Flexural strength is the force per unit area applied repeatedly at one fracture point of an object experiencing a flexural load. Flexural strength includes a combination of tensile strength tests and shear strength tests and is able to withstand the maximum load that can be received by a material. (13) According to the standard (ISO) 20795-1 in 2013, the minimum flexural strength is 65 MPa. (14) Based on research conducted by Sundari et al., the strength of hot polymerized acrylic resin and thermoplastic nylon after being soaked in coffee drinks can be weakened due to various factors, one of which is caused by food or drinks that have an acidic pH. (12) Meanwhile, based on research by Amalia et al. (2013), the base material of thermoplastic nylon soaked in an acidic solution can experience degradation so that the base weakens in withstanding the chewing load and eventually breaks. (15).

Based on the survey results from the Director of Biomaterial Science, University of Maryland School of Dentistry in Baltimore, it was stated that drinks with an acidic pH are isotonic drinks. One of the most popular isotonic drinks in the community is Pocari Sweat. Based on a sales survey of 7.64%, Pocari Sweat is an alternative drink to replace body ions and provide energy lost after physical activity. (16) The benefits of isotonic drinks for humans include replacing thirst during dehydration and having a composition such as water, chloride, calcium, potassium, sodium, and magnesium. Isotonic drinks contain several acids, such as phosphoric acid, malic acid, tartaric acid, and citric acid. (17) Based on research by Irawan (2007), athletes, especially soccer players, sweat around 2-2.5 liters in each match.

Several minerals, such as sodium, potassium, and chloride, in the body will come out with sweat during exercise to prevent dehydration in athletes. These three minerals must be replaced immediately because they play a role in maintaining the balance of body fluids. Research conducted by Safya (2017) on acrylic bases in carbonated drinks stated that there was a significant influence of carbonated drinks on the surface roughness of hot polymerized acrylic resin denture bases. (18)

MATERIAL & METHODS

Experimental laboratory research aimed to determine the flexural strength of hot polymerized acrylic resin denture base after immersion in isotonic drinks. The research sample was hot polymerized acrylic resin molded using a metal model according to the size for flexural strength testing based on ISO 20795-1 in 2013 (64 mm x 10 mm x 3.3 mm) ±0.2 mm.

RESULT & DISCUSSION

Normality Test of Flexural Strength Value Data on Hot Polymer Acrylic Resin Denture Bases in the Aquabidest Group and Pocari Sweat Group.

Table 1. Normality test of data from each gro**up**

Group	Shapiro Wilk	
	df	Sig
Aquabidest	6	0.501
Pocari Sweat	6	0.103

From Table 1, it can be seen that after conducting a normality test using the Shapiro-Wilk test based on the significance value ($p>0.05$), the data results were normally distributed because all groups had a value ($p>0.05$). Then, we continued with the Lavene homogeneity test. The significance result was 0.201, so the data in both groups were considered homogeneous.

Average Flexural Strength Value of Hot Polymerized Acrylic Denture Base in the Aquabidest Group and the Pocari Sweat Group. To find out the average flexural strength

value of the hot polymerized acrylic denture base in all groups, namely the Aquabidest group (control) and the Pocari Sweat drink immersion group, it can be seen in the following table:

Table 2. Mean Flexural Strength Values from all groups

Flexural Strength Value (Mpa)		
No. Spesimen	**Aquabidest**	**Pocari Sweat**
1	133.04	130.38
2	131.96	132.79
3	143.03	132.23
4	135.22	113.34
5	148.02	116.86
6	141.74	135.75
Mean ± SD	138.83 ± 6.39	126.89 ± 9.36

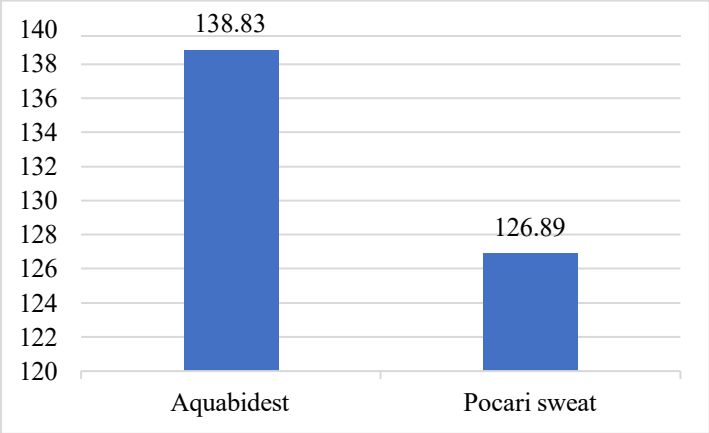

Figure 1. *Graph of Average Flexural Strength Values*

Table 2 and figure 1 show the flexural strength values for each immersion group. The average value in the aquabidest immersion group is greater, 138.83 MPa, compared to the average value in the Pocari Sweat immersion group, 126.89 MPa.

The flexural strength graph (Figure 1) shows a difference of 11.94 MPa between the average flexural strength values in the aquabidest group (control) and the Pocari Sweat drink immersion group. Therefore, the following statistical analysis was carried out to determine its significance.

Independent T-Test between the Hot Polymerized Acrylic Resin Denture Base Group, the Aquabidest Group, and the Pocari Sweat Group in the Flexural Strength Test.

Table 3. Independent T tests

		Sig. (2 tailed)
Result	Equal variances assumed	.027
	Equal variance not assumed	.030

Based on the results of the Independent T-test, the data results were obtained (P=0.027) with the hypothesis H0 rejected and H1 accepted. The data showed a significant difference between the aquabidest groups.

Acrylic resin is a denture material that is often used today. The basic material that is generally used is hot polymerized acrylic resin because it has good aesthetics, is easy to obtain and prepare, and is affordable. However, acrylic resin also has disadvantages, namely it is easily broken if dropped and can absorb water. Water absorption occurs through the diffusion process, where a substance moves through the resin cavity. These water molecules can penetrate the acrylic resin and occupy positions between the polymer chains, causing the polymer chains to be pushed and separated. Based on research conducted by Sormin et al. (2017), this water absorption causes changes in flexural strength, which can decrease or increase depending on how a person consumes food or drinks. (19)

The results of the study showed that the average flexural strength of the hot polymerized acrylic resin group (Vertex) without immersion in Pocari Sweat drinks was 138.83 MPa. The results of this control group are still greater than the minimum value of the flexural strength standard according to ISO 20795-1 in 2013 (65 MPa). (15) The flexural strength value of the control in this study is in accordance with other studies conducted by Sundari et al. (2016) regarding the flexural strength of hot polymerized acrylic resin and thermoplastic nylon after being soaked in Uleekareng coffee drink. Where the average value of the acrylic resin group soaked in coffee drink is still above the minimum standard of flexural strength, which is 94.27 MPa. (12)

The average value of each group in Table 2 and Graph 1 shows that the flexural strength value of the hot polymerized acrylic resin denture base soaked in aquabidest (control) has a value of 138.83 MPa. Meanwhile, the average value of the flexural strength in the hot

polymerized acrylic resin denture base group soaked in Pocari Sweat drink has a smaller average value, which is 126.89 MPa.

In this study, the flexural strength of the hot polymerized acrylic resin denture base soaked in Pocari Sweat drink (treatment) showed lower results because Pocari Sweat drink contains phosphoric acid, citric acid, malic acid, and tartaric acid which can affect the flexural strength in the oral cavity, so that the resin experiences a decrease in the matrix and a decrease in the flexural strength of the acrylic resin denture base. (20) Soaking acrylic resin in an acidic solution can certainly affect the strength of the denture base because the acidic solution enters the acrylic resin and fills the microporosity spaces, which causes changes in the molecular bonds of the acrylic resin. These changes in the molecular bonds of the acrylic resin can reduce the mechanical strength of the resin. (19) According to the matrix degradation theory, the resin base will absorb water molecules when soaked in water, and water will penetrate into the inter-molecular space of the polymer chain, then occupy a position between the polymer chains, causing the polymer chains to separate so that the polar interaction is reduced and can reduce the strength of the acrylic resin. (12)

Based on these results, soaking in Pocari Sweat drink for 5 days can cause a decrease in the flexural strength value. This is due to the nature of hot polymerized acrylic resin, which is able to absorb liquid when soaked in aquabidest or in Pocari Sweat drink. The decrease in flexural strength of the hot polymerized acrylic resin denture base can occur due to the higher acidity level in the soaking solution. In addition, it is assumed that the difference in pH levels between the two solutions also contributes to the decrease in flexural strength, where aquabidest has a pH. (6), while Pocari Sweat drink has a pH. (3). In other words, the hot polymerized acrylic resin denture base soaked in Pocari Sweat drink for 5 days can experience a decrease in flexural strength. These results are supported by previous research by Amalia et al. (2013), which stated that the process of decreasing flexural strength is caused by the acidity level (pH), which will affect the decrease in the ability to withstand chewing pressure and increase the risk of fracture in the denture base. (20) In addition, Annusavice's statement also supports that acrylic resin will experience saturation when soaked in water. (21).

CONCLUSION

Based on the study results above, it can be concluded that immersion of hot polymerized acrylic in isotonic drink solution can cause a decrease in flexural strength on the acrylic resin base. Suggestions are expected to be further research on changes in linear dimensions in isotonic drink immersion on the flexural strength of acrylic resin denture base.

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REFERENCE

1. Van Wambeke, P., Desomer, A., Ailiet, L., Berquin, A., Dumoulin, C., Depreitere, B., Dewachter, J. et al. Low back pain and radicular pain: Assessment and management. KCE Rep [Internet]. 2017;1–167. Available from: https://kce.fgov.be/sites/default/files/atoms/.../KCE_287_Low_back_pain_Report_2.pdf
2. WHO. Oral health. World Heal Organ. 2020;148(December):6.
3. RI K. Badan Penelitian dan Pengembangan Kesehatan. Riset Kesehatan Dasar (RISKESDAS). 2018.
4. Wahjuni S, Mandanie A. Pembuatan protesa kombinasi dengan *castable extracoronal attachments (laboratory procedure)*. J Vocat Heal Stud [Internet]. 2017;01(02):75–81. Available from: www.e-journal.unair.ac.id/index.php/JVHS
5. Lenggogeny P, Masulili SLC. Gigi Tiruan Sebagian Kerangka Logam sebagai Penunjang Kesehatan Jaringan Periodontal. Maj Kedokt Gigi Indones. 2015;20(2):123.
6. Rahmayani L, Melisa Idawani, Herwanda. Perilaku pemakai gigi tiruan terhadap pemeliharaan kebersihan gigi tiruan lepasan (Denture wearer's behavior towards removable denture cleansing care). Pdgi. 2013;62(3):83–8.
7. Catur S S, Silalahi PR, Mertisia I. Prosedur Pembuatan Gigi Tiruan Sebagian Lepasan Akrilik Pada Gigi 2 Untuk Menggantikan Gigi Tiruan Sebagian Nonformal. J Anal Kesehat. 2018;6(2):611.
8. El Hariri MA, El Sayed ME. Effect of nylon and acetal denture base material on Candida ablicans count for partial denture cases. Futur Dent J Egypt [Internet]. 2019;5(2):1. Available from: https://doi.org/10.1016/j.fdj.2019.01.001
9. Raszewski Z. Dynamics of different ion release from denture-base acrylic resins and their mechanical properties after the addition of bioactive materials. Saudi Dent J [Internet]. 2021;33(8):1071–7. Available from:

https://doi.org/10.1016/j.sdentj.2021.05.001
10. 20795-1 I. International Standard. 61010-1 © Iec2019. 2019;2019:268.
11. Fatihallah. Comparison of some mechanical properties of silanated SiO2 and polyester fiber composite incorporation into heat cured acrylic resin. 2015;
12. Sundari I PS& HM. Studi kekuatan fleksural antara resin akrilik heat cured dan termoplastik nilon setelah direndam dalam minuman kopi uleekareng (Coffea robusta). J Syiah Kuala Dent Soc 1, 51–58. 2016;
13. Fatimina AD, Benyamin B, Fathurrahman H. Pengaruh Posisi Serat Kaca (Fiberglass) Yang Berbeda Terhadap Kekuatan Fleksural Fiber Reinforced Acrylic Resin. ODONTO Dent J. 2016;3(2):128.
14. ISO. Dentistry — Base polymer. 2013;2013. Available from: https://standards.iteh.ai/catalog/standards/sist/Webwww.iso.orghttps://standards.iteh.ai/catalog/standards/sist/
15. Lee HH, Lee JH, Yang TH, Kim YJ, Kim SC, Kim GR, et al. Evaluation of the flexural mechanical properties of various thermoplastic denture base polymers. Dent Mater J. 2018;37(6):950–6.
16. Pratama F, Munandar JM. Analisis Brand Equity Pocari Sweat Dalam Persaingan Industri Minuman (Studi Kasus: Mahasiswa di Bogor). J Manaj dan Organ. 2016;1(1):24.
17. Habibullah. PENGARUH PEMBERIAN MINUMAN ISOTONIK TERHADAP STATUS HIDRASI CAIRAN TUBUH SETELAH MELAKUKAN JOGGING PADA SISWA SMA PLUS BUDI UTOMO MAKASSAR. 2015;359:6.
18. Lubis MDO, Putranti DT. Pengaruh Penambahan Aluminium Oksida Pada Bahan Basis Gigi Tiruan Resin Akrilik Polimerisasi Panas Terhadap Kekerasan Dan Kekasaran Permukaan. B-Dent J Kedokt Gigi Univ Baiturrahmah. 2019;6(1):1–8.
19. Sormin LTM, Rumampuk JF, Wowor VNS. Uji kekuatan transversal resin akrilik polimerisasi panas yang direndam dalam larutan cuka aren. e-GIGI. 2017;5(1).
20. Hafid IR, Sudibyo, Harniati ED. Kekuatan Transversa Termoplastik Nilon Pasca Perendaman Teh, Kopi dan Minuman Isotonik. Pros Semin Nas Mhs Unimu. 2019;1:12–3.
21. Dwimartha, Saputera, Wijayanti. Efek ekstrak jahe putih kecil 70% terhadap nilai kekerasan basis resin akrilik. 2018;